ENGINEERING NEWS

A JOURNAL OF CIVIL, MECHANICAL, MINING AND ELECTRICAL ENGINEERING

Vol. 61. No. 1. 220 Broadway, New York, January 7, 1909.

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The Granite Reef Dam and Gate Mechanism.

By F. TEICHMAN,* M. Am. Soc. C. E.

The Salt River Project, Arizona, irrigating about 210,000 acres of land of the Phoenix Valley, is one of the large irrigation works undertaken by the United States Reclamation Service. The Roosevelt Dam will create the storage reservoir of the project. It is situated about 60 miles distant from the land to be irrigated. About 55 miles below the Roosevelt Dam is built the diversion dam (called Granite Reef Dam), by means of which the water of the river is turned into the canals at both sides (north and south) of the river. The water thus turned into the canals is that of the tributaries of the Salt River below the Roosevelt Dam (especially the Verde River) and such water as is taken from above the dam to the river below the dam. There are three ways of passing this water from the river above the Roosevelt Dam: (1) through a power canal, 18 miles long, at about the crest of the dam, an elevation 240 ft. above the river level, there entering a penstock that runs to the power-house below the dam and about 21 ft. above the level of the river; (2) through a 10-ft. diameter pipe penetrating the dam, starting at its up-stream face at an elevation 75 ft. above river level and terminating in power-house; and (3) through the sluicing tunnel, 12 × 9 ft., that leads, at the level of the river, through the mountain side to the river below the dam. The water from the power canal passes through turbine wheels in power-house; that from the 10-ft. diameter pipe may in part or all be passed either through turbine wheels or directly into the river. The turbine wheels of power-house drive generators (total 5,400 KW.), and the power will be transmitted to the Phoenix Valley to be used principally for the pumping of water for the irrigation of about 20,000 acres. Of the 210,000 acres proposed to be irrigated under the project, there remain 190,000 acres to be irrigated by gravity. In accordance with the acreage on both sides of the river, the canal on the south side will have a capacity of 1,200 cu. ft. per sec.; that on the north side a capacity of 2,000 cu. ft. per sec.

To describe particularly the diversion dam† and the devices that turn the water into the two canals is the object of this article.

The Salt River is a very erratic stream, its minimum discharge at the site of the diversion dam is known to have been 55 sec.-ft.; its maximum flood discharge may have been 200,000 sec.-ft., and the variations are rapid. The presence of the Roosevelt Dam will considerably reduce the maximum flow at site of diversion dam by retaining the flood water above the dam or, with the reservoir filled, by equalizing the flow at flood times. To take care of the still large flood quantities without raising the water too high above the diversion dam, the latter was 1,000 ft., made long. At both ends of the dam it abuts against the intake structures.

Fig. 2 shows a plan of the intake structure for the south side of river, which is the head of a canal of 1,200 sec.-ft. capacity. The sluiceway of this structure has a floor about 40 ft. wide; it falls down-stream 1½%, and at line of dam it is 8 ft. lower than crest of dam. At the river side the sluiceway has a wall as high as the dam; at the land side a wall 15 ft. higher than dam. This latter wall is penetrated by nine openings 5 ft. high by 7 ft. wide for the nine regulator gates, the sill of the gates being 4 ft. below the crest of dam and from 4 to 3 ft. higher than floor of sluiceway. The sluiceway has at its lower end and in line of dam two sluice-gates 9 ft. high by 15 ft. wide, sills 8 ft. below the crest of dam. (Figs. 3-4.)

VIEW OF DAM AND DIVERSION WORKS LOOKING NORTH.

The leading considerations in giving the intake structure the form as described, are: The Salt River, like other Arizona streams, carries large amounts of sediment and drift, especially at flood times. The sediment will soon fill the river bed up to the crest of the dam. The sluiceway will have to be kept clear of sediment, so as not only to prevent the rolling of sediment through the regulator gates into the canal, but to have, if possible, the bottom of the stream, that passes by and feeds the regulator gates, several feet lower than the sill of the regulator gates, because in this manner the heavier grit, floating near the bottom of the stream, will be carried past the gate openings, and only the upper strata of the stream (for water at crest of dam) that contain less sediment, will be skimmed off into the canal. To keep the sluiceway clear of sediment, the two sluice-gates are either kept open slightly or they are opened periodically for a short time. To make the sluicing most efficient with the least amount of water both sluice-gates are made to open and close simultaneously. The water that is made to pass under the sluice-gates for the sake of keeping the sluiceway clear is not wasted for irrigation: (1) As long as the river carries only what is required for the two canals little sediment is carried by the river and little sluicing will be required to keep the sluiceway clear; (2) then there are a few independent irrigation canals that take their water from the river below the diversion dam, and they are entitled to a certain stipulated quantity of water, and if this is not flowing over the dam it can be turned into the river below the diversion dam by means of the sluice-gates; and (3) at a point of the river about half way on the front line of the irrigated land the rock comes close to the surface of the river and forces the underground water (water from under the dam and the drainage of the irrigated lands above this point and on both sides of the river) to the surface. At this point a low diversion dam of a temporary nature is built that turns the water into a canal, the lowest of the irrigated area, and part of the irrigation project.

The intake structure at the north side of river is of the same type as the one described for the south side of river, with slight differences in detail. On the north side the canal has a capacity of 2,000 sec.-ft.; the sluiceway is about 80 ft. wide; there are 18 regulator gates and four sluice gates.

The diversion dam and the intake structures are built of concrete. The gravel of the river formed one ingredient. The boulders excavated from the river bed were imbedded in the concrete to reduce cost per yard, wherever the nature of the concrete work permitted this. Steel reinforcement was used largely in the intake structures and in the joints of dam sections. All the construction work at the site of the dam was done by the government under force account.

The sluice-gates are operated by a chain and rope passing over superior and inferior pulley wheels, through a tunnel under the gates, around a drum to the cross-head of a hydraulic piston. This arrangement is shown in Fig. 3.

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*Designing Engineer, U. S. Reclamation Service, Phoenix, Ariz.

†The dam itself was described in our issue of Oct. 1, 1908, p. 360, in an article by Mr. J. D. Stannard, to which the reader is referred. It is of concrete of the usual gravity section but is peculiar in that it has projecting curtain walls extending down into the river bed to or near the rock bottom and a 71-ft. flat concrete slab as an apron in front of the section. The section is shown in Fig. 2a.—Ed.

The sluice-gate itself is shown in Fig. 5. It has at the up-stream face a cast-iron curved shell ⅝-in. thick, made in halves and riveted together in the field. The ends of the curved shell are held together by a number of ⅝ × 2½-in. tie-bars. The gate is filled with concrete, giving it a total weight of about 30,000 lbs. Each sluice-gate is suspended by two chains of 1½-in. metal, which are carried first over 31-in. diameter pocketed chain wheels, then down through the pier or abutment into a tunnel, then under 21-in. diameter chain wheels, then the chains connect with the two ends of a 1½-in. diameter steel rope, that is laid around a lug on the periphery of a steel drum of 7 ft. radius. There is one lug for each sluice-gate. These lugs are part of a cast-steel plate that is riveted to the periphery of the rope drum at the center of its arc. The steel plate has a second set of lugs closely adjoining the first set and around

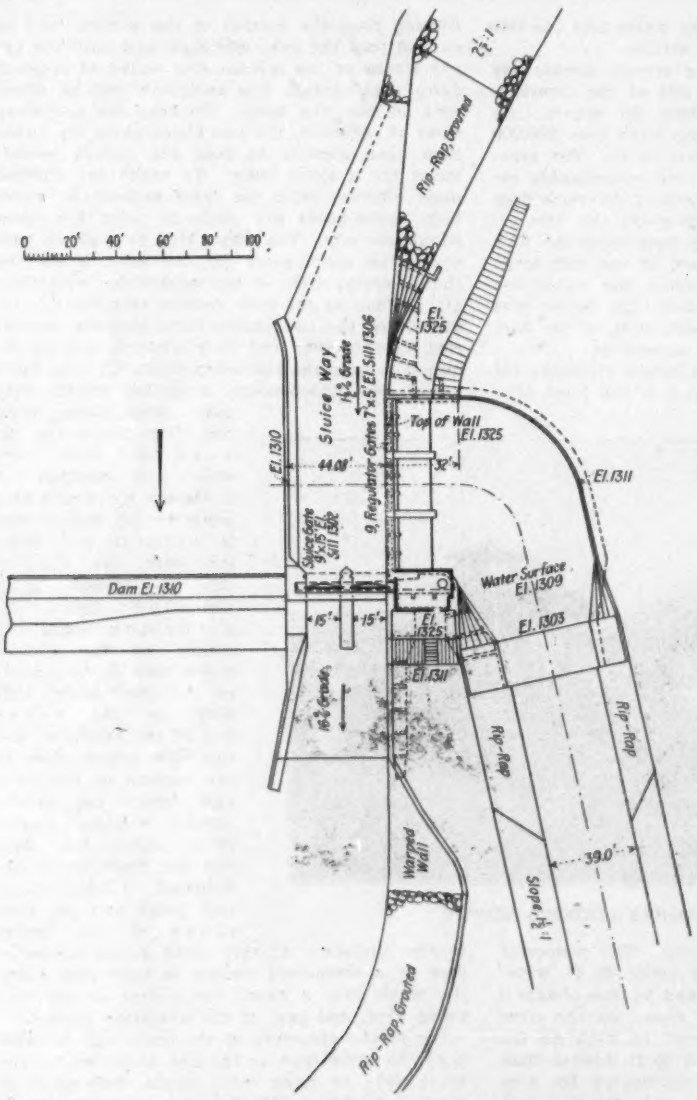


FIG. 2. PLAN SHOWING SLUICE-WAY AND INTAKE OF SOUTH SIDE CANAL AT GRANITE REEF DAM, SALT RIVER PROJECT, U. S. RECLAMATION SERVICE.

those lugs is laid another 1½-in. rope that connects the rope drum with the lower head of piston rod. The two ends of this rope are clamped together.

The piston rod enters an hydraulic cylinder, carries a piston and continues as a screw of square thread of large incline (Fig. 7). At the upper end the cylinder carries a steel casting through which the screw of the piston rod slides, being prevented from turning by feather and groove. Above the steel casting is carried, on ball bearings, the nut of the piston rod screw, with very small clearance between the nut and the upper annular face of steel casting. Between the lower face of nut and the upper ball race is bolted a rubber ring ⅝-in. thick. When raising or lowering the piston rod (or gates) the nut turns on the ball bearing and retains its position of little clearance over the rim of steel casting. The nut at the periphery has a bevel gear. Into this meshes a bevel pinion. While moving the gates this pinion is out of mesh, held there by its own weight. When the gates are to be locked in any position the pinion is pulled into mesh and by means of the chain wheel prevented from turning. A very slight downward motion of the piston will then compress the rubber ring above spoken of, the nut comes in contact with the annular face and seats itself there. Such a locking device—or a similar one—was considered requisite, so as to hold the gates in a permanent position for a long time, even with a leaking piston or with the pressure under the piston removed. Above the nut is shown a device that will automatically stop the progress of the piston (by opening a relief valve) in case the nut should not remain at its level but stick to the screw and be carried up with the same. The cylinder pressure may reach 700 lbs. per sq. in., i. e., at the North intake where there are four sluice-gates. The cylinder is made of 28-in. (outside diameter) lapwelded pipe, bored and brass lined.

The regulator gates (Fig. 8) are likewise formed by curved cast-iron shells, tied in by three sets of light angle irons. The oak sill is straight, and there results a buoyancy of the gate in excess of its weight. The gate stem is guided by a cross-head, and the gate screw (bronze) is held by a bronze nut in ball bearings. All nine gates (all 18 on the north side) are operated by one line shaft. The shaft of the 8-HP. gasoline engine carries two gears on the sleeves of a duplex friction clutch (Fig. 4). The gears transfer their motion to a countershaft, one gear directly, the other gear by means of an idler, thus reversing the motion. The lever that actuates the duplex clutch is operated by means of a ⅝-in. wire rope that passes by all the gate stands, near the floor, and is kept taut by weights at ends. This rope at each gate stand is laid around a small sheave, being prevented from slipping by passing through two holes in the rim. An operating lever can be stuck into lugs cast on these sheaves. Usually (at low river levels) three gates are moved at a time by placing their three bevel pinions in mesh with the bevel gears.

Mr. Louis C. Hill, Supervising Engineer U. S. Reclamation Service, is in charge of the Salt River Project (of which the Granite Reef Dam is a part). The Granite Reef Dam and the intake structures were designed by Mr. A. L. Harris, Assistant Engineer, the gates and mechanism were designed by the writer, and Mr. J. W. Martin, Constructing Engineer, had charge of the work in the field.

Wrought-Iron Cement-Lined Water Pip

By LEONARD METCALF†, M. Am. Soc. C. E.

In the course of the recent water-works valuation at Portland, Me., in which the plants of the Por Water Co., Standish Water & Construction Co., Go Water Co. and the Foreside Water Co. were appra the writer had occasion to look up experience in England with wrought-iron cement-lined water pip search of the files of current engineering journals oped some articles of interest, referred to in the b ography appended to this paper, and led to the sen of an assistant, Mr. William L. Butcher, a member this Association, to interview the superintendents several of the New England plants upon their experie with the wrought-iron cement-lined water pipes in th works. The data thus acquired, with certain observatio and deductions by the writer, have been brought to gether in this form in the hope of eliciting a general discussion upon the merits and demerits of wrought-iro cement-lined pipe, by members of this Association, many of whom have had personal experience with it.

Type of Construction.

Two general methods of building wrought-iron cement-lined pipe have been used in this country; the first, known locally, perhaps, as the Goodhue & Birnie pipe; the second, what is known as the Phipps patent.

The Goodhue & Birnie pipe was generally made by riveting up sheets of wrought iron, single riveted with cold rivets, without any attempt to make the joints watertight, and lining this wrought-iron shell with from ¾ to 1-in. of neat Rosendale cement, or cement mortar mixed one part of cement to one part of sand. This work was generally done in a central plant, or at different points along the pipe line, from which the pipe was carried to the trench, there imbedded in Rosendale ce-

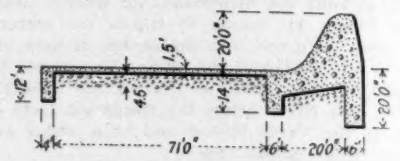


Fig. 2a. Section Through Dam.

ment mortar laid along the bottom of the trench, and then covered over the sides and top with a ¾ to 1-in. layer or casing of Rosendale cement mortar plastered on with rubber gloves or trowel in the hands of the pipe maker. The trench was generally backfilled immediately or shortly after laying the pipe.

The pipes were made in lengths of 9 ft., and the joints between the pipes were made by means of a sleeve of wrought iron with inner and outer casing of cement, or by making the pipe tapering so that the end of one pipe was fitted into the end of the next. In the larger mains the joints were often plastered on the inside after laying; in the smaller ones, this was, of course, not attempted.

The Phipps patent pipe was generally made and coated without as well as within with a ¾ to 1-in. layer of cement or cement mortar, the outer coating being held in place by a thin sheet of wrought iron which subsequently rusted out in the trench. This outer sheet was of distinct advantage, however, as a protection to the outer cement coating in the handling and laying of the pipe.

In a few cases cast-iron bells and spigots have been riveted to the wrought-iron sheets before making the pipe, and the joints have then been made in the ordinary manner with lead tightly caulked in place or by the use of cement mortar.

More recently, under the Phipps patent, a type of cast-iron ring has been developed which is driven home in each end of the pipe,—one of the rings being a female ring, the other a male ring—thus more rigidly holding the end of the pipe and preventing injury to it in transportation and laying, and incidentally making more convenient the placing of the outer cement coating of the pipe, which is made of grout poured into the mold between the inner and outer sheets, with the pipe standing on end. The joint between pipes is made finally by the use of a sleeve as heretofore.

So far as the writer is aware no cast-iron joint has thus far been developed which has proven thoroughly satisfactory and advantageous from the standpoint of economy.

It is perhaps worthy of note that while blue annealed wrought-iron sheets imported from England were used in many of the early installations, in making the later ones steel has been substituted at some saving in cost, though not in durability.

Early History.

A glimpse of the early history or experience with wrought-iron cement-lined water pipe is given in the report of the well-known engineer, Mr. Phineas Ball, of

*Greatly condensed from a paper presented before the New England Water Works Association, Dec. 9, 1908. The full paper, with discussion, will appear in the Journal of the Association.

†Of Metcalf & Eddy, Consulting Engineers, Boston, Mass.

Worcester, Mass., to the city of Springfield, to be found in the report of the Board of Water Commissioners to the City Council for the year 1876, which is quoted below at some length:

Extract from Report of Phineas Ball, dated at Springfield, Mass., Jan. 15, 1876.

OF WROUGHT-IRON AND CEMENT-LINED PIPE IN GENERAL.

There is always in every community a certain number of intelligent citizens who entertain honest doubts as to the utility of using this kind of pipe. In the minds of many of the citizens of the city, this doubt has existed and still exists. Under various forms during the last two and a half years this want of confidence has been freely expressed by many. After an experience of twelve years in laying and watching wrought-iron and cement-lined pipe, and having examined many samples of pipe removed for various causes, and after examining defects that have appeared under a variety of conditions, and made many inquiries into the immediate cause leading to individual defects, and having consulted with those of large experience with this kind of pipe, your indulgence is claimed to express upon this subject a more direct and a more explicit opinion than I have ever heretofore given in any previous paper or report.

* * * * * * *

In the usual mode of making and laying this kind of pipe, my experience has forced upon me the conclusion that there are *two prominent causes which have constantly operated to defeat the protective property of the cement as applied to the iron.* The *first* lies in the fact that the *iron shells have not been made watertight previous to the application of the cement.* Nor is this defect completely remedied either in the manner of lining or laying, as is commonly supposed.

The *second is the use of sand with the cement* as in case of ordinary mortar.

In the making of the shells, usually, no pretense has been made of making riveted joints watertight. To secure a watertight joint along the riveted laps, reliance has been had entirely upon the cement lining to fill up and make proof against the exit of water any space left open in the riveting. That many pieces are thus made watertight there is ample evidence. But that the vast majority of pipes are not watertight at the riveted laps is too painfully evident from the inspection of any considerable number of pipes taken up that have been in use a number of years. That leaks so large as to require to be "mended" do occur upon the riveted laps is well known to all experienced in the care of this kind of pipe. This form of "leak" is not as common as the one at the joint, but still frequent enough to reveal the fact that in this respect it is a defect that needs attention and the application of a remedy. Where one leak of this kind appears on the surface, many more, very small, indeed, occur, only the result of a slight oozing through the cement lining, but sufficient to lift the covering from the outside of the iron and thus commence and continue the oxidation of the iron, until the pipe is ruined.

My experience has convinced me that leaks of this small character are far more common and numerous upon laps than at joints. That, as a rule, if a joint leaks, sooner or later it will make its appearance at the surface of the ground.

The second point, that of the use of sand with cement, making it into mortar the same as that used for ordinary stone and brick work, I deem important. It is cement which possesses the peculiar property of preventing oxidation and not sand. Sand dilutes the cement and makes the resulting mass less adhesive when applied to the iron, and decreases the tensile strength of the hardened mortar.

The original patent for this kind of pipe was granted to Jonathan Ball, of New York City, dated Dec. 15, 1843. The claims in the original patent are as follows, to wit: "What I claim as my invention is the application of hydraulic cement or water cement as a coating upon the interior surface of metallic water pipes to prevent the corrosion and oxidation of the metals of which the pipes are composed. Also the means by which it is accomplished, as set forth."

The original patent was reissued Sept. 15, 1857. In this reissue the word "cement" is used 14 times; "hydraulic cement" four times, and "Roman cement" once; while the word "sand" does not occur and there is no reference whatever to its use in connection with cement by any form of expression or phraseology used in the document. In practice, however, singularly enough, from the earliest application of the device, the cement was always used mixed with sand in the same manner as in mason work. The earliest recorded line of pipe laid under this patent is one mentioned in the circular of the Patent Water & Gas-Pipe Co., under the date of 1875, by whom it was introduced as being laid in Jersey City in 1845, and referred to in a certificate of Samuel McElroy as having been examined by him March 20, 1867. The next oldest line mentioned was laid at Saratoga in 1847, since which time the pipe has been laid in many cities and towns. From time to time various defects appeared, mostly in the destruction of the iron of the pipe by rust. Some of these appeared quite anomalous because no satisfactory reason could be given for their occurrence. For these defects and anomalies the common explanation given was that the cement mortar, meaning the cement and sand, was not properly mixed, or in some cases loam or clay would accidentally get mixed with the mortar and form a very porous mortar, or clay or loam coming in contact with the pipe before the cement covering was applied, by all of which means oxidation was induced. After very diligent inquiry in 1873 and previously of many persons of much experience with this kind of pipe, want of uniformity of mixing the mortar seemed to be the unanimous opinion as the prime cause of all, or nearly all, of the defects observed to that time. On your works the defects of imperfect mixing was remedied, where any sand has been used, by mixing the mortar by machinery.

* * * * * * *

The conclusions, therefore, at present reached may be summarized as follows:

(1). That wrought iron as a material of which to make water pipes is much more reliable than cast, with a great economy in the employment of materials.

(2). That the sheet-iron shells should be made watertight before lining with or laying in cement.

(3). That in applying the cement no admixture of sand should be allowed.

(4). That owing to the economy with which this pipe can be laid, generally, as compared with cast iron, especially for large sizes, if laid with watertight shells and in pure cement, its use will reply the investment.

Present experience has brought me to the foregoing conclusions. They are not put forth as final. Further evidence upon the behavior of pipe laid upon the method indicated might lead me to reject the pipe altogether, but until that adverse evidence is received my opinion is that there are many localities in which it may be used for the public benefit. The pipe has many good qualities in its favor, and by a careful study of the facts which relate to its preservation the practice of the principles upon which its permanence rests may be so perfected that it may be as safe to lay this kind of pipe as cast iron. In concluding this subject, I will add that all of the wrought-iron pipe laid on the works this year has been lined and covered with pure cement, without sand, and that more than half of that laid last year was first covered with a layer of about one-quarter inch in thickness before the sand mortar was put on.

[Here follows abstracts of various other reports on the subject in hand.—Ed.]

Early in the present year, 1908, to bring down to date the opinions formed in the various towns referred to in the above citations, the writer sent one of his assistants to interview the superintendents of water-works in a number of our New England cities using pipe of this character, and to look up such references on the subject as he might be able to find. The result of these inquiries, together with some material collected in Lynn by Mr. E. V. French,* kindly placed at the disposal of the writer, and some inquiries and observations of the writer, are shown in the following memoranda:

[A summary only of these memoranda is given further on, except that we reprint in full the accounts given of some pipe tests in Lynn, Mass., of pipe making at Plymouth, Mass., and what is given regarding Portland, Me.—Ed.]

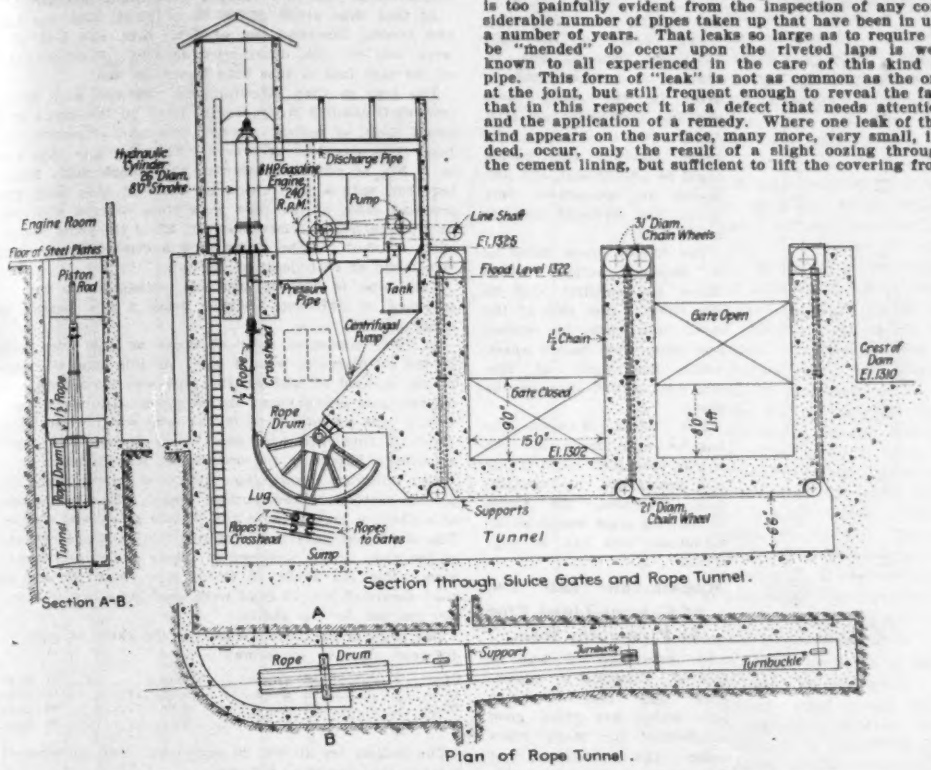
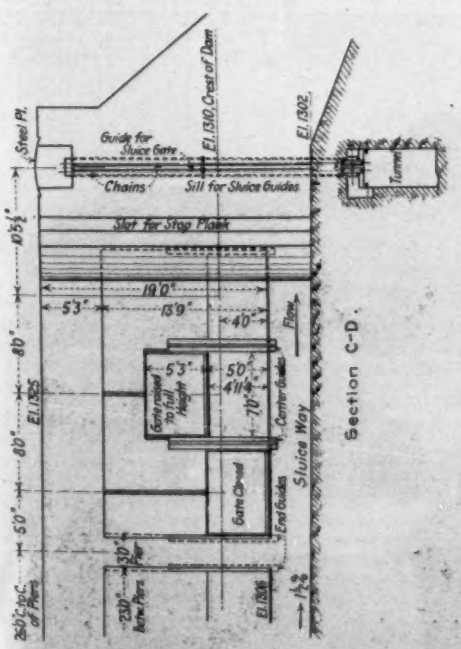


FIG. 3. DETAILS OF OPERATING MECHANISM OF THE SLUICE GATES.



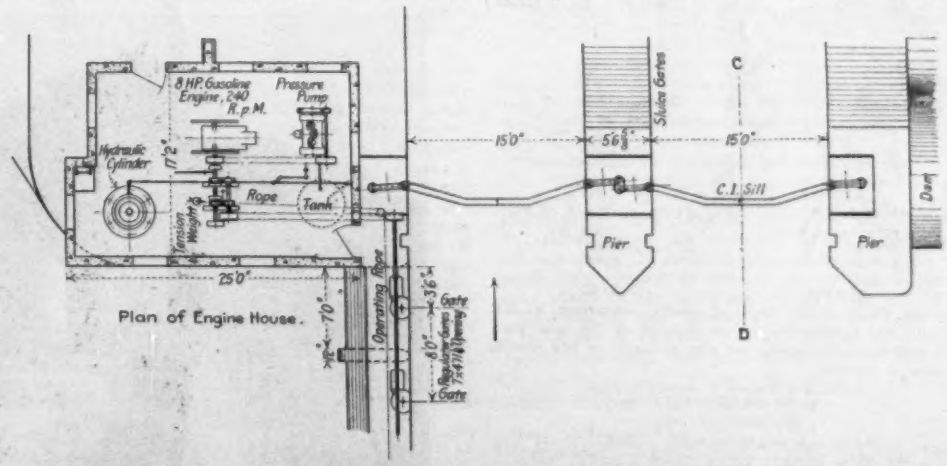


FIG. 4. ENGINE HOUSE, SLUICE GATES AND REGULATOR GATES, GRANITE REEF DIVERSION DAM, ARIZONA.

Test of 16-in. and 4-in. Cement-Lined Pipe, from Lynn, Mass., Water-Works.

Specimens of the plate and longitudinal joints were secured and tested in a Riehle machine at the Massachusetts Institute of Technology, through the kindness of Prof. Miller, and with the assistance of C. W. Mowry. These samples were more or less pitted and weakened on the surface by rust caused by exposure to weather, with the outside coat of cement removed.

*Vice-President of the Arkwright Insurance Company and a member of this Association.

The 16-in. pipe was laid in 1870 and remained in service until last fall. The shell is said to be sheet iron. It is riveted longitudinally by a single riveted lap joint. Each length of pipe consisted of 3-ft. sections riveted together by single riveted lap joints. The rivets were iron and were riveted cold. The joints between lengths were made as described above.

The 4-in. pipe was probably laid about 1881-1883. The shell is said to be sheet iron. It is riveted longitudinally by a single riveted lap joint. The rivets were iron and were riveted cold. The joints between lengths were made in the same manner as in the case of the 16-in. pipe.

	16-in.	4-in.
Diameter of shell	17½ ins.	4⅝ ins.
Thickness of plate	5/64 "	1/32 "
Size of rivets	¼ " (diam.)	¼ " (diam.)
Pitch of rivets in longitudinal joint	1 "	1 "
Pitch of rivets in ring seam	4½ "	.....
Lap	1⅛ "	⅞ "

RESULT OF TEST, 16-IN. PIPE.

Tensile Strength per in. of Width of Plate.

First specimen	3,159 lbs.
Second "	2,567 "
Third "	3,098 "
Average	2,941 "

Strength of Longitudinal Joint per in. of Width of Plate.

First specimen	2,057 lbs.
Second "	1,920 "
Third "	2,060 "
Average	2,012 "

Load on pipe per inch of length, assuming 50 lbs. steady water pressure on the interior of the iron pipe. No allowance was made for any strength in the cement lining or coating.

$$\text{Load} = \text{Pressure} \times \text{radius of pipe.}$$
$$= 50 \times 8.75 = 437.5 \text{ lbs.}$$

Efficiency of Joint.

$$\text{Efficiency} = \frac{\text{Strength of joint}}{\text{Strength of plate}} = \frac{2,012}{2,941} = 0.68$$
$$= 68\%.$$

Factor of Safety.

$$\text{Factor of safety} = \frac{\text{Strength of joint}}{\text{Load on pipe}} = \frac{2,012}{437.5} = 4.6$$

RESULT OF TEST, 4-IN. PIPE.

Tensile Strength per Inch of Width of Plate.

First specimen	781 lbs.
Second "	888 "
Third "	863 "
Average	844 "

Strength of Longitudinal Joint per in. of Width of Plate.

First specimen	833 lbs.
Second "	830 "
Average	831 "

Load on pipe per inch of length, assuming 50 lbs. steady water pressure on the interior of the iron pipe. No allowance was made for any strength in the cement lining or coating.

$$\text{Load} = \text{Pressure} \times \text{radius of pipe.}$$
$$= 50 \times 2.375 = 119 \text{ lbs.}$$

Efficiency of Joint.

$$\text{Efficiency} = \frac{\text{Strength of plate}}{\text{Strength of joint}} = \frac{831}{844} = .98$$
$$= 98\%.$$

Factor of Safety.

$$\text{Factor of safety} = \frac{\text{Strength of joint}}{\text{Load on pipe}} = \frac{831}{119} = 7.$$

The failure of the plate in every instance was indicated by a sudden halt or drop in the scale beam showing practically no elasticity in the plate. In every fracture the lamina could be plainly seen and presented an appearance very much like wrought iron or mild steel.

The riveted joints failed by a bending action, which threw an eccentric load on the rivets. One side of the rivet was thus in tension and some were pulled apart, while the heads of others were pulled through the plate.

The joints between the lengths were made in such a way that they could transmit practically no tension, and, therefore, the stress in the ring seam would be insignificant and can be neglected.

Manufacture and Use of Cement-Lined Pipe At Plymouth, Mass.

In substance it may be said of Plymouth's experience that they have a pipe which has given good satisfaction for many years under the conditions of their service; they are able to manufacture and lay it with some degree of economy; the maintenance of it is neither excessively expensive nor annoying; it furnishes them with clear, clean water; the friction loss in it does not appear to be excessive, and the original diameter of pipe remains substantially unchanged after years of service. Hence they naturally have no cause to regret the adoption of cement-lined pipe and have no hesitancy in continuing its use.

Report.

Plymouth is a town of about eleven thousand inhabitants and has had a water supply since 1796. Until 1855 the water was supplied to the town by a private company and the pipes they used were wooden logs with holes bored in them. In 1855 the town purchased the plant from the Aqueduct Company, and the use of cement-lined pipe in Plymouth dates from that period.

At that time about 16,000 ft. of 10-in. pipe was laid and several thousand feet of 8-in., 6-in. and 4-in. pipe were laid for the distribution system. Practically all of the pipe laid at that time is still in use.

The pipe as then manufactured consisted of a sheet-iron shell about 9 ft. in length, lined on the inside with about ½-in. of cement mortar, composed of cement and sand in proportions of 1 to 1. The pipe was then laid in a bed of cement mortar in the trench, ends butted together, with a steel sleeve or collar at each joint. The top and sides of the pipe were then covered with two or more inches of cement mortar, all of the same proportions as used for the lining, and a cement-mortar joint was made at each joint of the pipe.

This pipe is still in use and withstands a varying pressure in different sections, from a few pounds to about 50 lbs.

In 1900, somewhat over 40 miles of pipe from 4 to 20 ins. in diameter was in use. At this time a change in the method of making the pipe was introduced, and for the past seven years all extensions have been made with a pipe manufactured in the local water-works shop, which is furnished with mechanical devices and power machinery necessary for economical manufacture.

The following description will, it is hoped, make the present method of construction clear. The pipe consists of a shell, a jacket, male and female rings, and sleeves. The shells and jackets are of soft steel and are received at the shop in flat rectangular sheets of proper size and gage. For the shells of 18-in. pipe about 30 tons of steel sheets of No. 13 gage were used, at a cost of about $50 per ton for the sheets.

The gage of the sheets used for the shells of pipes of different sizes is as follows:

24-in.	12 gage	10-in.	17 gage
18-in.	13 gage	8-in.	18 gage
16-in.	13 gage	6-in.	19 gage
12-in.	15 gage	4-in.	20 gage

The jackets are all No. 26 gage iron. The operation of making the pipe is as follows:

The shells are punched in a punching machine. The spacing of the rivet holes is ¾-in. c. to c., the edge of the rivet hole being ⅝-in. from the edge of the sheet. The sheets are then put into the rolls and given a semi-circular form, as two sheets are used for the manufacture of one shell for the 18-in. pipe. After being rolled, the shells are riveted by hand, using 816 rivets with a 3½-lb. hammer, on a stake, so-called, which is simply a bar of iron about 10 ft. long, the upper surface of which is curved to approximately the same radius as the shell

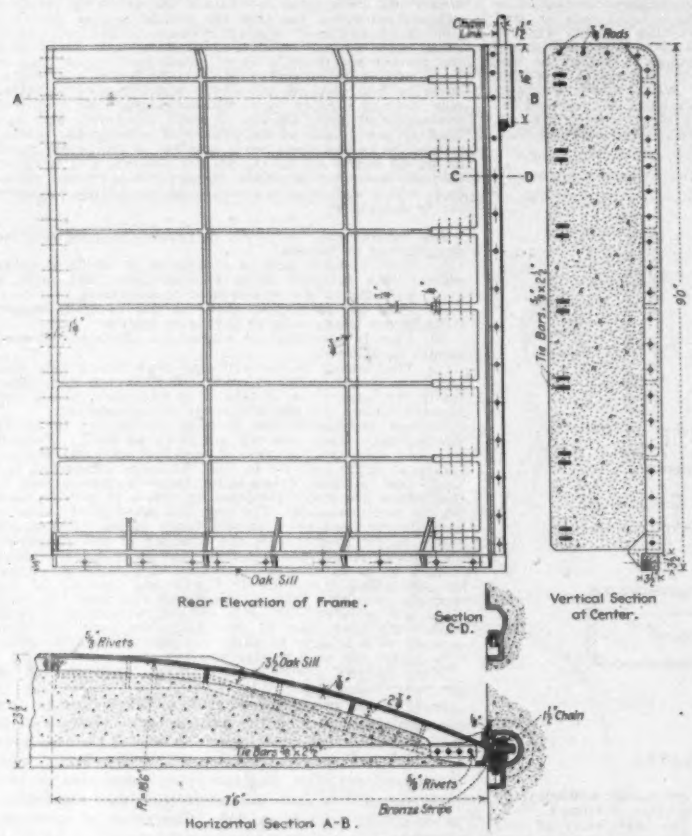


Fig. 5. Details of Sluice Gate.

FIG. 6. VIEW OF NORTH CANAL GATES.
(Showing sluice gates in foreground and regulator gates in right middle distance.)

of the pipe which is to be riveted. The jackets are punched, rolled, and riveted in precisely the same manner as the shells and are 1½ ins. larger in diameter.

The rings are of cast-iron, a male ring for one end of the shell and a female ring for the other, the female ring being concave and the male ring convex, thus enabling a very tight joint to be made when the pipes are fitted together in the trench. About thirty tons of these rings were used in the manufacture of 16 and 18-in. pipe during the past year and the cost of the rings was 4 cts. per lb.

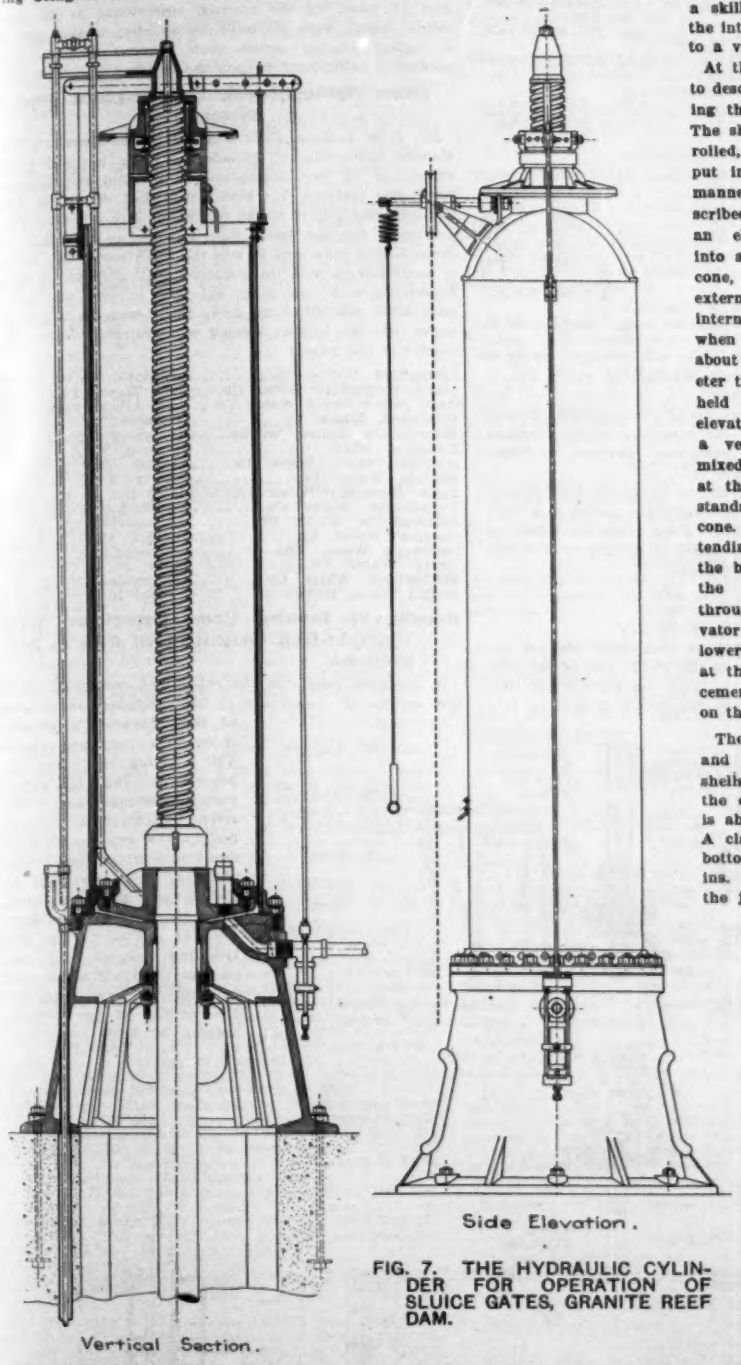


FIG. 7. THE HYDRAULIC CYLINDER FOR OPERATION OF SLUICE GATES, GRANITE REEF DAM.

The next operation, after the shells are riveted, is the fitting in of the rings, and as they are made just for a driving fit into the shell they are driven in by use of the maul. After the rings are in place the shells for the 18-in., 16-in. and 14-in. pipes are lined by hand, and the smaller sizes of shell from 12-in. to 4-in. are lined by means of a revolving cone. Neat Rosendale cement is used in lining. About 3,000 bbls. of cement have been used during the past year in the manufacture of pipe, and the cost was $1.20 per bbl., delivered at our shop.

When the shells are ready to be lined by hand they are placed horizontally on two horses. A man stands at each end of the pipe with a long-handled pallet knife, so-called, to spread the cement smoothly in the pipe. This knife is simply a flat blade about 1½ ins. wide and 4 ins. in length, with a handle about 4 ft. long. The cement for lining is mixed by hand in mixing boxes, and there are two men to mix for the two men who line. As the pipe lies on the horses it is lined for its whole length and half way up each side. Then the cement is allowed to set, after which the pipe is rolled over and the remaining half lined. After the cement has been smoothly spread about ½-in. thick, on the inside of the pipe, any irregularities which appear are corrected by the use of the "nigger-head," which is a stiff brush on the end of a long handle. This brush in the hands of a skillful workman can bring the interior of the cement pipes to a very smooth surface.

At this point it may be well to describe the operation of lining the smaller sizes of pipe. The shells having been punched, rolled, and riveted, and rings put in in precisely the same manner as previously described, are stood upright on an elevator which descends into a pit. In this pit is the cone, so-called, which has an external diameter equal to the internal diameter of the shell when lined—in other words, about an inch smaller in diameter than the shell—placed and held directly over it on the elevator. The tone revolves on a vertical axis and cement mixed by machinery is put in at the top of the shell as it stands on the elevator over the cone. The top of the cone, extending for a few inches into the bottom of the shell, holds the cement from falling through into the pit. The elevator holding the shell is then lowered and the cone revolving at the same time spreads the cement smoothly and uniformly on the inside of the shell.

The next operation is filling and grouting the pipe. The shells are stood on end around the edge of a platform which is about 6 ft. above the floor. A clamp is placed around the bottom of the shell about 8 ins. from the lower end, and the jacket lowered from above fits into the clamp at the bottom. The jacket is kept symmetrical with the shell at the bottom by means of this clamp, and at the top by means of four wedges. The grout is merely a mixture of neat cement and water, mixed to such a consistency that it will pour readily, and is mixed by machinery in a cylindrical mixer which has four paddles. After being thoroughly mixed, the grout is poured into a metal bucket which is suspended by a chain with a wheel and is carried on a track around the platform. The grout is poured from the bucket between the shell and jacket of the pipe that has been stood around the edge of the platform. After the grout has been poured, the pipes are allowed to set twelve hours, when the cement is usually hard enough to permit of handling them. The pipes are then loaded upon a truck, taken to the yard, cleaned, and painted with a coal-tar paint. After staying in the yard about two weeks they are sufficiently hard to permit of being loaded upon a wagon and carted to the trench.

Tables Nos. I. and II. show respectively the cost of making and laying the largest cement-lined pipes which have been made at Plymouth. Town labor, only, is used, and $2 is the wage paid for a working day of eight hours, for each laborer. The foreman receives $3.

The pipe-making gang numbers about sixteen men, but only four are kept on the regular gang and the others are hired as they are needed.

TABLE III.—RECORD OF LEAKS IN CEMENT-LINED WROUGHT-IRON PIPE AT PLYMOUTH, MASS.

Year.	Miles pipe.	Leaks—No.	Leaks—Per mile.	Total cost of leaks—Total.	Total cost of leaks—Per mile.	Total cost of leaks—Per leak.
1874.....	....	9	....	$47.30	....	....
1875.....	....	53	....	249.45	....	....
1876.....	....	8	....	42.75	....	....
1877.....	....	9	....	42.87	....	....
1878.....	....	14	....	43.05	....	....
1879.....	....	7	....	23.25	....	....
1880.....	19.6	57	2.85	253.11	$12.90*	$4.44
1881.....	20.34	72	3.54	321.06	15.74	4.46
1882.....	20.54	33	1.6	159.22	7.75	4.83
1883.....	20.85	22	1.05	159.52	7.65	7.26
1884.....	21.52	46	2.13	263.46	12.24	5.73
1885.....	21.75	30	1.32	174.28	8.01	5.81
1886.....	23.6	38	1.61	231.91	9.82	6.10
1887.....	27.37	55	2.0	385.64	14.09†	7.02
1888.....	28.21	89	3.15	592.29	20.96	6.66
1889.....	28.7	31	1.08	261.90	9.13	8.45
1890.....	29.05	32	1.1	150.63	5.18	4.71
1891.....	29.23	35	1.18	201.79	6.90	5.77
1892.....	32.00	35	1.09	207.83	6.49	5.94
1893.....	33.09	39	1.11	204.74	6.19	5.24
1894.....	33.4	41	1.22	241.02	7.22	5.88
1895.....	34.32	34	.99	179.91	5.24	5.29
1896.....	34.45	46	1.34	310.13	9.00	6.74
1897.....	35.00	50	1.43	389.10	11.12	7.79
1898.....	35.17	42	1.2	232.84	6.62	5.54
1899.....	36.07	100	2.71	468.42	12.98‡	4.30
1900.....	37.33	58	1.55	402.35	10.78	6.94
1901.....	44.43	102	2.29	733.42	16.50§	7.19
1902.....	45.56	81	1.77	782.07	17.16	9.66
1903.....	45.8	54	1.20	496.81	10.90	9.20
1904.....	46.44	59	1.27	438.75	9.44‖	7.44
1905.....	46.88	41	.87	516.40	11.02‖	12.60
1906.....	47.33	25	.53	315.40	6.67	12.61
1907.....	49.43	26	.52	622.45	12.56‡	23.92
Average... (1880-1907.)	33.12	49.36	1.40	$349.86	$10.56	$7.09

*1880. Pump started April, 1880.
†1887. High service put on Dec. 20, 1887, causing many extra leaks in pipe 34 years old, never before exposed to high pressure.
‡1899. Lightning caused 30 or 40 leaks.
§1901. Twelve leaks occurred in old 2-in. galvanized iron. Since replaced.
‖1904 and 1906. Extremely cold; frost many places 5 ft. deep. 300 ft. pipe lowered.
‡1907. This year one leak was very expensive. Frost was 5 ft. deep. Leak did not appear on surface for several days, causing a settling in sidewalk and street, which had to be replaced.

Experience at Portland, Me.

(Information developed in the valuation proceedings in the suit of the Portland Water District vs. Portland Water Co., et als., March, 1908.)

In the years 1868-9 the Portland Water Co. laid a 20-in. wrought-iron cement-lined supply main, about 15.2 miles long, from Sebago Lake to the city of Portland. Data as to the cost of this main are unfortunately lacking.

In the years 1875-9, however, a second wrought-iron cement-lined supply main was laid from the lake to the city. The upper portion of this, approximately 3½ miles in length, was 26 ins. in diameter; the lower portion, approximately 11.4 miles in length, 24 ins. diameter. The actual cost of this compound main was fortunately developed from the books of the company and is given in substance on page 6, as some of the unit costs to be derived therefrom are interesting and valuable.

(The original pipe distribution, comprising pipes from 4 to 16 ins. in diameter, was also laid of wrought-iron cement-lined pipe, but substantially all of this was

TABLE I.—COST OF MAKING CEMENT-LINED PIPE AT PLYMOUTH, MASS.

Date.	Size, ins.	Length, ft.	Shell.	Jacket.	Sleeve.	Rings.	Rivets.	Cement.	Paint.	Labor.	Total.	Cost per ft.
1901.....	6	5,283	$650.94	$326.90	$42.25	$154.17	$25.98	$356.30	$7.14	$513.30	$2,076.98	$0.393
1901.....	4	2,461	186.20	104.74	12.37	43.89	12.29	162.15	1.50	281.25	804.39	0.326
1901.....	10	5,097	146.08	407.43	88.42	255.17	36.42	551.55	10.67	885.45	3,381.29	0.663
1901.....	6	2,007	221.84	100.71	14.02	58.18	10.05	135.41	2.06	177.09	719.44	0.358
1901.....	12	981	305.28	182.40	25.07	55.12	7.00	121.26	2.67	177.08	875.88	0.893
1907.....	16	8,109	3,722.80	852.72	$37.50	1,363.35	61.90	1,728.00	15.00	1,954.42	10.035.69	1.24
1907.....	14	2,183	953.44	190.40	50.00	318.60	23.60	384.68	5.00	535.72	2,479.40	1.13
1907.....	18	7,680	3,751.60	896.40	$296.80	1,460.80	119.00	1,826.00	18.00	2,457.60	10,828.20	1.41

TABLE II.—COST OF LAYING CEMENT-LINED PIPE AT PLYMOUTH, MASS.

Date.	Size, ins.	Length, ft.	Labor.	Branches, gate and hydrant.	Pipe.	Miscellaneous. Cement	Miscellaneous.	Total.	Cost per ft.	Remarks.
1901.....	12	1,292	$861.90	$418.81	$1,128.62	$70.20	$55.00	$2,534.53	$1.96	Also 47 ft. 6-in. pipe.
1901.....	10	5,430	2,478.28	1,292.21	3,583.47	205.40	173.48	7,732.84	1.43	105 ft. 6-in., 77 ft. 12-in., 40 ft. 8-in.
1901.....	12	1,292	458.40	106.72	1,153.76	52.00	54.22	1,827.10	1.41	
1904.....	8	3,007	1,035.66	275.67	1,503.50	91.20	72.99	2,979.02	0.99	
1904.....	6	2,543	1,134.97	412.33	933.28	61.88	37.55	2,584.01	1.02	
1905.....	6	4,550	1,854.23	491.38	1,966.16	96.00	385.82	4,793.59	1.05	Includes 4 hydrants and changing 25 services.
1907.....	18	6,545	4,248.80	282.00	9,228.45	440.60	523.60	14,673.45	2.24	
1907.....	14	2,031	552.52	141.00	2,295.03	124.20	86.00	3,201.27	1.58	
1907.....	16	8,891	4,820.00	1,411.12	11,024.84	420.00	1,179.39	18,855.35	2.12	

abandoned within a period of twenty years, and relaid with cast-iron pipe, and figures of its cost are not available.)

It should be stated that the static pressures upon this supply main are approximately as follows:

4	miles, under	0— 40	lbs. per sq. in.
2.7	miles, under	40— 60	lbs. per sq. in.
4.9	miles, under	60— 80	lbs. per sq. in.
2.3	miles, under	80—100	lbs. per sq. in.
0.9	miles, under	100—120	lbs. per sq. in.

The main is stated to have been built with a factor of safety of approximately 3, but the computation of the factor of safety under several assumed heads indicates that the actual factor of safety is probably not in excess of 1.5 at the points of maximum pressure, assuming always static pressures, and ignoring alike the decrease in pressure due to friction and the increase in pressure due to water hammer or other causes.

TABLE IIIa.—STRENGTH OF RIVETING OF WROUGHT-IRON CEMENT-LINED PIPE BETWEEN SEBAGO LAKE AND PORTLAND.

Wrought-iron plate, No. 12 and No. 14 gage; tensile strength	60,000* lbs. per sq. in.
Wrought-iron plate, No. 12 and No. 14 gage; bearing strength	60,000* lbs. per sq. in.
Rivets of wrought iron; shearing strength	50,000 lbs. per sq. in.
For field riveting, allow, shearing strength	40,000 lbs. per sq. in.
Efficiency of best single riveted joint	55%
Efficiency of best double riveted joint	70%

*For 3/16-in. and heavier plate, tensile strength = 50,000 lbs. per sq. in.

March 27, 1908, examined another section of 20-in. cement-lined pipe and found following measurement:

TABLE IV.—MEASUREMENTS AND OTHER DATA OF CEMENT-LINED WROUGHT-IRON PIPE AT PORTLAND WATER-WORKS.

Internal diameter of wrought-iron cement-lined pipe, ins.	19¾ & 19¾	24	26
External diameter of wrought-iron shell, ins.	22 & 21¾	26	28
Type of joint	Slip	Sleeve	Sleeve
Gage of plate (Birmingham)	14	12	12
Thickness of plate, ins.	0.083	0.109	0.109
Rivets, diameter, ins.	¾	⅞	⅞
Rivets, pitch, ins.	1¼	1	1
Riveting	Single	Single	Single
Under Assumed Head of 250 ft. (= 108 lbs. per sq. in.) from Sebago Lake:			
Tension on plate, lbs. per sq. in.	14,200	12,900*	
Factor of safety (60,000)	2.3	2.6	
Shear upon rivets, lbs. per sq. in.	29,900	12,700	
Factor of safety (40,000)	1.4	3.1	
Bearing upon plate, lbs. per sq. in.	70,700	34,400	
Factor of safety (60,000), (based on 100,000 lbs. = 1.4)	Failure	1.7	
Under Assumed Head of 200 ft. (= 87 lbs. per sq. in.) from Full Stand-pipe.			
Tension on plate	11,400	10,400*	
Factor of safety	2.8	3.2	
Shear	24,000	10,100	
Factor of safety	1.6	4.0	
Bearing	56,500	27,500	
Factor of safety (based on 100,000 lbs. = 1.8)	Failure	2.2	
Under Assumed Head of 150 ft. (= 65 lbs. per sq. in.) from Bramhall Reservoir.			
Tension on plate	8,500	7,700*	
Factor of safety	3.9	4.3	
Shear	18,000	7,600	
Factor of safety	2.2	5.3	
Bearing	42,500	20,700	
Factor of safety (based on 100,000 lbs. = 2.4)	1.4	1.5	

Note.—No allowance for water hammer. A factor of safety of 1.0 is equivalent to failure. *The 26-in. is under very small pressure.

In comparison with these factors of safety of 1½ to 3 or more, it should be noted that modern steel pipes are usually built with a factor of safety of 5 (or at least 4) and cast-iron pipes with a factor of safety of 15 more or less.

TABLE V.—COST OF BUILDING 60,221 FT. 24-IN. WROUGHT-IRON CEMENT-LINED SUPPLY PIPE FROM END OF 26-IN PIPE ON WARD'S HILL TO THE CITY OF PORTLAND, IN THE YEAR 1878-9.

Rights of way, land damages, etc.		$1,579.14
Cast-iron pipe, specials, castings, valves, etc.		5,024.08
Wrought-iron sheets for pipe:		
441,502 lbs. at 2.43 cts.	$10,728.50	
1,449,562 lbs. at 2.30 cts.	33,339.92	
		44,068.42
Making pipes 9 ft. long: 1,593 pieces at $2.15, and 5,073 pieces at $2.00		13,570.95
Making joint rings, inside rings and special rings: 7,061 rings, weighing 646,310 lbs., at 1.95 cts., approximately, per lb.		12,615.14
Total labor, 24,775 days, at $1.28 approximate average; day labor being paid from $1 to $1.25; foremen, $3.50		31,807.11
Cement, 20,621 bbls. Rosendale		20,180.50
Freight, cartage, etc.		4,148.91
Engineering, incidentals and miscellaneous expenses, amounting to 8.32%, approximately		10,919.67
		$143,913.92
Deduct land damages		1,579.14
Net amount		$142,334.78
Cost per foot		$2.36
Equivalent cost per foot for year 1908 (estimated)		$3.02

TABLE VI.—COST OF BUILDING 18,450 FT. 26-IN. WROUGHT-IRON CEMENT-LINED PIPE FROM SEBAGO LAKE TO THE JUNCTION ON WARD'S HILL WITH 24-IN. PIPE LEADING TO THE CITY OF PORTLAND, IN 1875-6.

	Per lb., cts.	Actual cost in 1875-6.	Equivalent prices as of 1908.
Wrought-iron sheets, No. 12 Birmingham gage, 635,679 lbs., at	3.32	$21,230	$18,670
Trimming, rolling, riveting and finishing 2,066 pipe 9 ft. long, at $2.50, equivalent to	0.78	5,020	4,430
Rings	0.90	5,590	4,920
Total, 1875-6	5.0		
Total, 1908	4.4		
Cement (Rosendale), 74,071 bbls., at $1.30 and $1.53½ per bbl.		10,170	7,500
Contract for laying		28,310	42,465
Valves		237	237
Specials		85	85
Lumber		608	1,074
Contract work		141	150
Total		$71,391	$79,531
Cost per foot (including 11.4% for engineering and contingencies)		$3.87	$4.31

The cost of this 26-in. pipe line was excessive, owing to deep cut work, a considerable amount of which was in quicksand.

Mr. Allen Hazen, who was one of the engineers retained by the Water District in the valuation of the Portland water-works, made the interesting analysis of these items of cost given in Table VII.

Pitometer gagings were made of the mains from Sebago Lake to the city of Portland covering a period of a little over one month, March, 1908. From these the following coefficients of discharge applicable to the Hazen-Williams hydraulic formula were determined:

26-in., c = 100,
24-in., c = 100,
20-in., c = 90,

but there was reason to believe that there was an unknown cross connection from the 26-in. and 24-in. compound high-service line to the 20-in. low-service pipe line. This makes it *probable that the actual coefficient (for Hazen-Williams' formula) was about* c = 95 *for all three of these pipe lines.*

This coefficient is as low as would be expected from cast-iron pipe of like age and was a surprise to the engineers, who had looked for a coefficient of from 110 to 120. The low value is probably to be accounted for, in part at least, by the internal restrictions at the pipe joints, which were plastered inside after laying, and to a slightly smaller actual than nominal diameter (the coefficient being figured upon the nominal pipe diameter).

Other Wrought-Iron Cement-Lined Pipe Systems.

Mr. J. W. Ledoux, Chief Engineer of the American Pipe Manufacturing Co., of Philadelphia, who has had much experience in the installation of wrought-iron cement-lined pipe systems, has kindly furnished the writer with the following list of works for which a considerable proportion if not the entire pipe system has been built of cement-lined pipe, and it was the intention of the writer to communicate with these water-works in regard to their experience with this pipe, but lack of time and space have alike prevented his doing so, though he is still in hopes that Mr. Ledoux himself will contribute to the discussion of this paper:

Springfield Water Co.	Lansdown, Pa.
North Springfield Water Co.	Bryn Mawr, Pa.
East Jersey Coast Water Co.	West Asbury Park, N. J.
Wildwood Water Co.	Wildwood, N. J.
Moorestown Water Works	Moorestown, N. J.
Riverton Water Co.	Riverton, N. J.
Norfolk County Water Co.	Norfolk, Va.
Sumter Water Co.	Sumter, S. C.
Paris Mountain Water Co.	Greenville, S. C.
Tallahassee Water Co.	Tallahassee, Fla.
Milledgeville Water Co.	Milledgeville, Ga.
Opelika Water Co.	Opelika, Ala.
LaGrange Water Co.	LaGrange, Ga.
Derry Water Co.	Derry, Pa.
Skaneateles Water Co.	Skaneateles, N. Y.
Jordan Water Works	Jordan, N. Y.

Results of Inquiry Upon Experience With Wrought-Iron Cement-Lined Pipe in New England.

In order to bring into convenient and comparable form the results of experience in New England with pipe of this character a parallel column is subjoined (Table VIII.) giving the views expressed in 1888 by water-works superintendents in different communities as typified by the data contained in our Engineering News article and the views developed by the writer 20 years later, that is, in the year 1908, first, as applied to pipe distribution systems, and second, as to supply mains; and in Table IX. are condensed the results of the writer's inquiry in 1908.

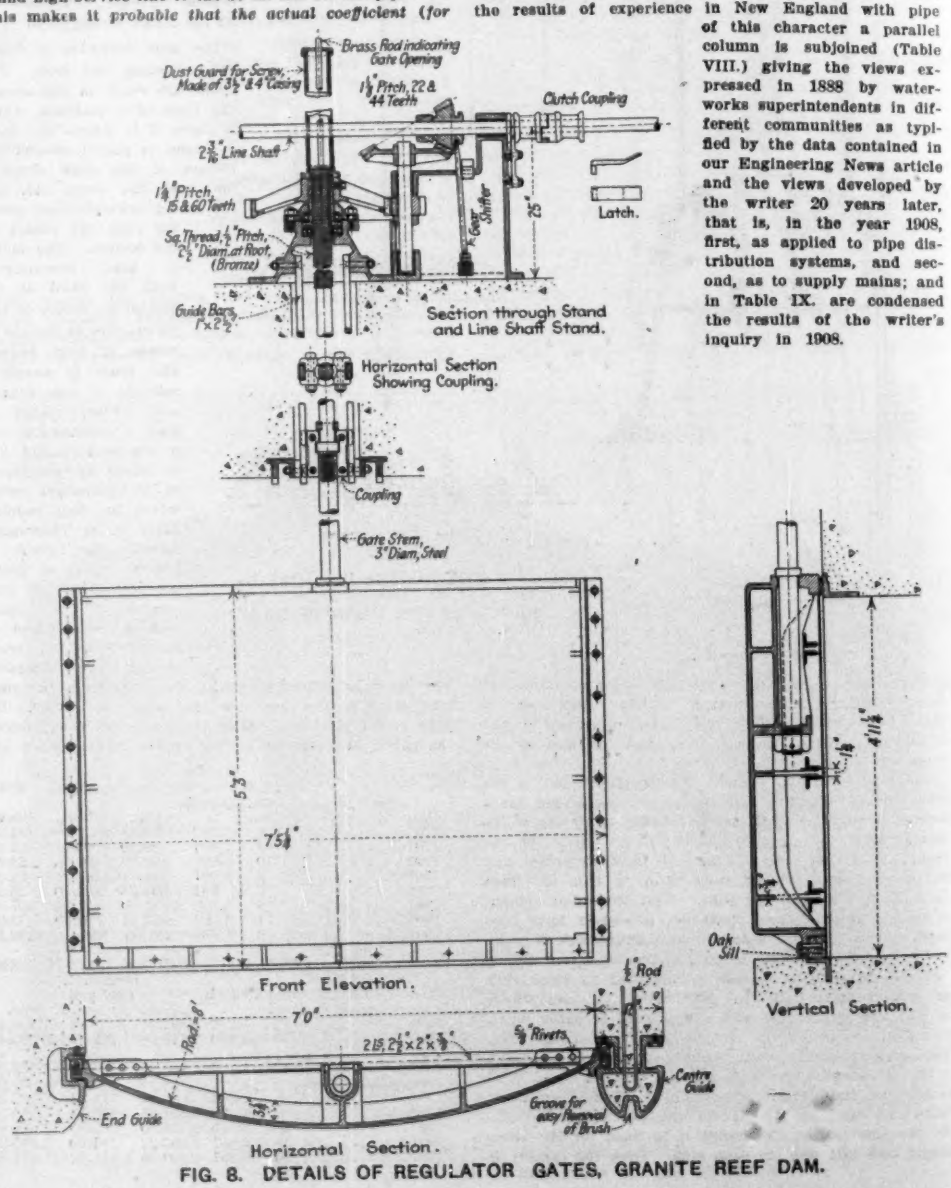


FIG. 8. DETAILS OF REGULATOR GATES, GRANITE REEF DAM.

TABLE VII.—ESTIMATE OF COST OF REPRODUCING CEMENT-LINED PIPE AT PORTLAND.

	26-In.		24-In.		20-In.
	Actual price and quantity.	Estimates for present conditions.	Actual price and quantity.	Estimates for present conditions.	Estimates for present conditions.
Cost of sheets, per lb.	$0.0342	$0.0275	$0.0233	$0.0275	$0.0275
Cost of cement, per bbl.	1.40	1.00	0.98	1.00	1.00
Cost of joint castings, per lb.	0.0280	0.0275	0.0195	0.0275	0.0275
Cost of making pipe, per lb.	0.00736	0.0125	0.00718	0.0125	0.0125
Weight per foot, lbs.	37.0	.....	31.4	.....	21.0
Bbls. cement per ft.	0.405	.....	0.342	.....	0.310
Wght. joint rings, lb.	71.0	.....	91 0	.....	70.0
Co. per ft.	8.3	.....	10.7	.....	8.2
Cost per lin. ft. of:					
Sheets	$1.26	$1.02	$0.73	$0.86	$0.58
Making pipe	0.28	0.46	0.23	0.39	0.26
Joint castings	0.23	0.23	0.21	0.29	0.23
Cement	0.57	0.40	0.33	0.34	0.31
Gates, valves, etc.	0.05	0.04	0.08	0.07	0.06
Labor and laying	1.48*	2.22	0.53	0.80	1.25
Sum	$3.87	$4.37	$2.11	$2.75	$2.69
Total actual cost, including all special obstacles, engineering and contingencies	$3.86	.....	$2.39	.....	.....
Ratio of total cost to sum of items above given	1.00	.....	1.13	.....	$1.06
Total estimated cost, including engineering and contingencies	.....	$4.37	.....	$3.10	2.85
Fair value to use is estimate on which 14% for engineering and contingencies is to be added	....	3.85	.....	2.72	2.50

*The contract price at ordinary depths of cut, and exclusive of rock, was 70 cts. per lin. ft. The difference, 78 cts. per ft., represents the additional allowances for extra depth and for rock and for tunnel, and for all contingencies because of the character of the ground. These additional costs would naturally be somewhat higher on the 26-in. line than on the 24-in. line, and the route of the 20-in. line covers substantially the same space as that occupied by both the 26-in. and 24-in. lines.

Reports Upon Cement-Lined Supply Mains.

Brockton, Mass., has a 20 and 24-in. pipe, about 3 miles long, one half of it running through a country district, the remainder through one of the outlying streets of the city. The latter half of the main has numerous connections. The original pipe shell was dipped in hot asphaltum and rolled in cement and sand before being placed. The lower end of the main is under about 50 lbs. pressure.

1908. Superintendent states that there has been no trouble to speak of with this main during the 28 years of its existence.

Concord, Mass. 1908. Has two 10-in. pipes, approximately 2½ miles each in length, laid from Sandy Pond to the town, the first in the year 1874 and the second in the year 1883. Both pipes are still in active service and have given comparatively little trouble from leakage. The maximum static pressure is approximately 40 lbs.

Concord, N. H., in 1872 laid a 14-in. cement-lined main from Penacook Pond to the city. This main was about 2 miles long, laid largely through a country district, and was under a pressure of about 60 lbs. per sq. in.

1908. The work of relaying this pipe with cast iron was commenced in 1897 and completed in 1901.

In 1883 a low-service main 18 ins. in diameter, about 2 miles long, was laid, and in 1887 a high-service main 14 ins. in diameter, about 2½ miles long, was laid, the latter being known as the Penacook extension.

1908. These two last-mentioned mains are said to have given no trouble up to the present time.

Manchester, N. H., has a main about 4 miles long, laid in 1872; part of this is between the pumps and the reservoir, the lower part being subjected to about 60 lbs. pressure. This wrought-iron cement-lined pipe has cast-iron bells and lead joints.

1908. This pipe is still in use.

Plymouth, Mass., laid in 1855 a 10-in. main, about 3 miles long, the lower part under a pressure of approximately 50 lbs.

1908. This pipe is still in use and in good condition. A new 18-in. wrought-iron cement-lined supply main is being laid this year from the source of supply to the pumping station and thence to the town.

Portland, Me. A 20-in. wrought-iron cement-lined supply main about 15.2 miles long was laid from Sebago Lake to the city of Portland in the years 1868 to 1869. In the years 1875-9 a second wrought-iron cement-lined pipe supply main was laid from the lake to the city. The upper portion of this, approximately 3½ miles in length, was 26 ins. in diameter; the lower portion, approximately 11.4 miles in length, was 24 ins. in diameter. (In 1901 the construction of the third line from the lake of 30-in. cast-iron pipe was begun and has not yet been completed).

1908. These two wrought-iron cement-lined mains are still in active service, though the construction of a new steel pipe capable of supplying the entire demands of the city will probably be begun next year, in which case the wrought-iron cement-lined pipes will be held as reserves only. Although there has been more or less trouble from leakage, these mains have done good service.

Springfield, Mass., laid in 1874 a 24-in. main about 10½ miles long from Ludlow reservoir to the city.

1908. The engineer of the department states that he understands that a considerable portion of it was relaid during the first year after construction, but that since that time little or no repairs have been necessary.

As summed up in a word, wrought-iron cement-lined pipe has, generally speaking, proved disadvantageous for water-works uses *in distribution pipe systems*, except in comparatively small communities where street excavations and underground disturbances are of comparatively rare or unusual occurrence and where the pressure upon the pipes has been of moderate amount.

TABLE VIII.—EXPERIENCE WITH AND OPINIONS UPON WROUGHT-IRON CEMENT-LINED DISTRIBUTION PIPE IN VARIOUS CITIES UP TO THE YEAR 1888 AND IN THE YEAR 1908.

1888.	1908.
Boston, Mass.	
Gave it up on account of rusting and bursting.	Using cast-iron pipe only.
Brockton, Mass.	
Reports cement-lined pipe all right and no leaks.	No distribution pipe. Only three miles supply pipe.
Brooklyn, N. Y.	
Used it from 1859 to 1884 and gave it up as unserviceable.	Using cast-iron pipe only.
Cambridge, Mass.	
None laid for 15 years.	Using cast-iron and steel pipe.
Chelsea, Mass.	
Used some such pipe for 21 years and its condition is fairly good, but cast-iron pipe was found to be more reliable and economical.	None remains. Using cast-iron only.
Concord, N. H.	
Has used cement pipe for 16 years. It is in good condition.	Began replacement in 1898; 14 out of 28 miles in 1887 now in use.
Fitchburg, Mass.	
Used it from 14 to 17 years, but gave it up because repairs cost more than the change to cast-iron pipe.	Using cast-iron pipe.
Hartford, Conn.	
Has 12 miles of cement-lined pipe and has used it for 25 years, but it has given much trouble from breaks.	Using cast-iron pipe.
Malden, Mass.	
Laid some 20 years ago and is replacing it with cast-iron.	Using cast-iron pipe.
Manchester, N. H.	
Used it for 15 years, but is not laying any more on account of leaks and breaks.	Cast-iron pipe.
Meriden, Conn.	
Has used it since 1869. Condition poor.	Cast-iron pipe.
New Bedford, Mass.	
Considers it unreliable.	Cast-iron pipe.
New Haven, Conn.	
Considers it reliable and contemplates no change.	Cast-iron pipe.
New London, Conn.	
Would on no account lay a large main of cement-lined pipe, and small mains only with the best of materials and workmanship.	Eight miles (out of 22 in 1886) remain.
Pittsfield, Mass.	
Used it since 1855. Condition good so far as known.	None remains.
Plymouth, Mass.	
Using cement-lined pipe exclusively.	Still using cement-lined pipe exclusively. Giving good satisfaction.
Portland, Me.	
After 20 years' experience has taken all the cement-lined distribution pipe up because it could not stand the pressure. Supply mains in good condition.	Cast-iron pipe only for distribution system. Supply mains still in use, but new cast-iron pipe or steel mains will probably soon be laid.
Providence, R. I.	
Considers the pipe treacherous.	Cast-iron pipe.
Salem, Mass.	
In use for 20 years and considered good.	Appropriations recently made to replace cement-lined pipe with cast iron.
Somerville, Mass.	
Eighty breaks a year.	Using cast-iron pipe.
Waltham, Mass.	
Reports that as pipe is beginning to rust no more of it will be laid.	Only one mile of it remains.
Woburn, Mass.	
Reports it perfect for pressure of 60 to 95 lbs. Does not contemplate change.	In 1899 abandoned further extension work of cement-lined pipe in favor of cast-iron pipe.
Worcester, Mass.	
Had a little in use for 12 to 16 years, but the condition is poor, owing to frequent leaks.	None remains.

In *conduit* or *supply pipe* service, wrought-iron cement-lined pipe has given much greater satisfaction and has made on the whole a good record for itself, except where the pressure has been great or the pipe has been liable to disturbance by reason of insecure foundation, neighboring excavations, etc.

Advantages and Disadvantages of Wrought-Iron Cement-Lined Pipe, as Compared With Cast-Iron Pipe.

The advantages and disadvantages of wrought-iron cement-lined pipe as compared with cast-iron pipe may be briefly summarized as follows:

ADVANTAGES.—(1) Freedom from tuberculation, resulting in a comparatively small loss in carrying capacity during the life of the pipe.

(2) Reasonably high carrying capacity—technically referred to as high coefficient of discharge—though less than that of new cast-iron pipe.

(3) Longevity and durability under favorable circumstances.

(4) Lower first cost when compared with cast-iron pipe costing over $27, or thereabouts, per ton.

DISADVANTAGES.—(1) Absolute and relatively greater dependence upon good materials and good work in the manufacture and laying of the pipe.

(2) Greater danger of bad or slipshod work in use of cement-lined rather than of cast-iron pipe, particularly in wet trenches or in localities affording insecure foundations.

(3) Greater cost than cast-iron pipe under average conditions. (The approximately comparable cost of cast-iron pipe being $27 per ton or thereabouts, and the average price of cast-iron pipe about $25.)

(4) Unreliability and danger from bad foundations and nearby excavations made at any time after the completion of the pipe line.

(5) Small factor of safety and consequent danger from water hammer, careless manipulation of gates, etc. (The usual factor of safety in wrought-iron cement-lined pipes has been from 3 to 4, in steel pipes from 4 to 5, and in cast-iron pipes from 12 to 15.)

(6) Resulting lower limits of safe pressures. Desirable limit, in the opinion of the writer, 65 lbs. per sq. in.; in the opinion of the chief engineer of the American Pipe Manufacturing Co., 100 lbs. per sq. in.

(7) The carrying capacity or coefficient of discharge may not differ materially from that of old cast-iron pipe if the cement pipe is badly made or laid.

(8) Danger from lightning and liability of more extended damage therefrom.

(9) Difficulty in making watertight joints and connections.

(10) Repairs not so easily, cheaply, quickly, or effectively made as for cast-iron pipe.

(11) Difficulty in making service pipe connections and greater likelihood of leakage.

Carrying Capacity.

There can be no doubt that the cement coating in the interior of a wrought-iron cement-lined pipe is more satisfactory than the coating of the cast iron, so far as its effect upon the quality of the water is concerned, though the difference may be, and perhaps generally is, practically insignificant. No coating has thus far been found for cast-iron pipe which does not under average conditions sooner or later permit tuberculation. The rapidity and amount of this tuberculation varies with the quality of the pipe coating. Any excrescence of this sort must unquestionably decrease the discharging capacity of the pipe line. This fact is recognized in the design of our cast-iron pipe systems by the adoption of a pipe size or diameter which shall cover this progressive loss in carrying capacity. In other words, the pipe is designed for future rather than for present conditions.

The chief claim of the wrought-iron cement-lined pipe advocates has always been the freedom from tuberculation and maintenance in carrying capacity of pipe of this character, and it is probably true that the carrying capacity of wrought-iron cement-lined pipe decreases but slightly during the life of the pipe under ordinary conditions.

Comparatively little information has been published of the actual carrying capacities of wrought-iron cement-lined pipes. Without attempting a technical discussion upon this matter, it may suffice to refer to a few examples of recent gagings of pipe of this character. Hazen and Williams in their hydraulic tables quote a range of coefficients for use in the Hazen and Williams formula of the following amount:

Experimenter.	Diameter ins.	No. of observations	Range of velocity ft. per sec.	Range of c in H.-W. formula	Mean value of c.
Fanning.	20	11	1.49-4.04	127-118	122*
Bazin...	31.50	10	2.78-6.60	148-144	146*

Remarks: *Cement-lined iron. *Experimental conduit.

but the writer is inclined to regard these values as distinctly too high under conditions in this country, so far as he has observed them, though he recognizes and regrets the existing lack of specific data upon this subject.

Pitometer gagings covering a period of four weeks upon the 20-in. and the compound 26-24-in. wrought-iron cement-lined water mains of the Portland Water Co. conduit during the recent valuation proceedings indicate a coefficient of discharge in the Hazen and Williams formula of $c = 95$, though it is probably true that had the pipe been true to nominal diameter the coefficient would have approximated $c = 98$.*

Some recent and crude observations at Greensburg seem to indicate a value of approximately $c = 100$, but

*Approximate gagings at Plymouth, Mass., indicate a value of $c = 103$ to 107.

more accurate experiments with Venturi meters are soon to be made.

The coefficient of the Springfield, Mass., cement-lined pipe is believed to approximate $c = 110$.

As compared with these coefficients of discharge for wrought-iron cement-lined pipe for use in the Hazen and Williams formula, the relative discharging capacity of cast-iron pipe may be said to be approximately as follows:

For new cast-iron pipe .....$c = 130$-140.
For cast-iron pipe 25 years more or less old.$c = 100$

While it is true that the coefficient for old cast-iron pipe, 35 years or more in age, may be as low as $c = 90$ or even 80, it should be borne in mind that growth in population and hence in water consumption and other causes usually results in the construction of additional supply mains, considerably within the limits of this period, and in such cases the new main is often built sufficiently large to care for the entire consumption of the community without the assistance of the old main. For this reason, and inasmuch as the experience with the modern pipe coating has been comparatively short, it seems reasonable to make a comparison of carrying capacities upon the following basis:

For wrought-iron cement-lined pipe.....$c = 120$.
For new cast-iron pipe .....$c = 130$.
For old cast-iron pipe .....$c = 100$.

Referring by c to the coefficient of discharge to be used in the Hazen and Williams formula. (This formula has been used by the writer as one of the reliable hydraulic formulas now in common use, and as the *most convenient* one on account of its ready application through the Hazen and Williams slide rule.) But attention is called to the fact that in a number of wrought-iron cement-lined pipe lines the actual coefficient c, as based upon the nominal diameter of pipe, varies from $c = 95$ to $c = 110$, and the assumption of a value of $c = 110$ or even $c = 100$ is, therefore, believed to afford a much sounder basis of design than the assumption of the above coefficient of $c = 120$. The difference in the actual process of making pipe must result in far greater variation in internal diameters in cement-lined than in cast-iron pipes, and this is, therefore, an essential factor in design. In order to do full justice to the cement-lined pipe, however, the coefficient $c = 120$ has been assumed for it in the following discussion. If the true coefficient of discharge should be found to be less, in the light of further information, the following figures should be corrected in accordance therewith.

Relative Carrying Capacity of Wrought-Iron Cement-Lined and Cast-Iron Pipe.

The relative carrying capacity of wrought-iron cement-lined and cast-iron pipes, based upon the above stated coefficients of discharge ($c = 120$ for wrought-iron cement-lined pipe; $c = 130$ for new cast-iron pipe; $c = 100$ for old cast-iron pipe) as applied to the Hazen and Williams hydraulic formula, *is shown by the direct ratio between the assumed coefficients of discharge;* that is, upon the above assumptions, new cast-iron pipe will discharge $^1/_{13}$ more than wrought-iron cement-lined pipe under equal heads, and old cast-iron pipe will discharge but $^{10}/_{12}$ as much as cement-lined pipe under like heads.

Or, to put the matter in a different way, the same discharge can be had in cast-iron and wrought-iron cement-lined pipes of like diameter with different friction losses shown in Table X.

TABLE X.—COMPARATIVE FRICTION LOSSES IN CEMENT-LINED PIPE AND IN NEW AND OLD CAST-IRON PIPE.

Internal diam. of pipe, in. (1)	Velocity in ft. per second. (2)	Discharge in gals. per 24 hrs. (3)	Friction loss in ft. Cement lined $C = 120$.* Per 1,000 ft. (4)	Per mile. (5)	New cast-iron $C = 130$.* Per 1,000 ft. (6)	Per mile. (7)	Old cast-iron $C = 100$.* Per 1,000 ft. (8)	Per mile. (9)
8	1	226,000	0.6	3	0.55	3	0.96	5
	3	677,000	4.5	24	4.2	22	7.3	39
	5	1,127,000	11.6	61	10.8	57	18.9	100
12	1	508,000	0.43	2	0.37	2	0.6	3
	3	1,523,000	3.3	17	2.8	15	4.6	24
	5	2,538,000	8.4	44	7.2	38	11.8	62
16	1	902,000	0.31	2	0.26	1	0.42	2
	3	2,707,000	2.3	12	2.0	11	3.3	17
	5	4,512,000	6.0	32	5.2	27	8.4	44
20	1	1,410,000	0.24	1	0.20	1	0.33	2
	3	4,230,000	1.8	10	1.56	8	2.5	13
	5	7,050,000	4.6	24	4.0	21	6.5	34

*For use in Hazen and Williams formula.

Or, if we figure (upon the above assumptions) the necessary diameter of an *old* cast-iron pipe system to give a discharge equal to that of a wrought-iron cement-lined pipe under like head or friction loss, we find the following approximate results, within a range of velocities of from 1 to 5 ft. per sec.:

Internal diameter (ins.) of wrought-iron cement-lined pipe. ($c = 120$.)	Necessary diameter (ins.) of *old* cast-iron pipe for equivalent discharging capacity under equal heads. ($c = 100$.)	Increase in diameter, %.
8	8.8	10.0%
12	12.8	10.7%
16	17.2	10.7%
20	21.4	10.7%

It appears, therefore, that under the assumed conditions (as to coefficient of discharge for use in Hazen and Williams formula, for cement-lined pipe, $c = 120$; for old cast-iron pipe, $c = 100$) the cast-iron pipe in order to have the same carrying capacity as the wrought-iron cement-lined pipe at the end of a period of twenty-five years more or less *must be 10% or thereabouts larger in diameter.*

The effect of this increase in diameter upon the relative cost of the pipe is discussed further on.

Cement Lining as a Preservative of the Metal.

Past experience with wrought-iron and steel pipes indicates the distinct superiority of the former metal for water-works pipe lines. Unfortunately, however, it is impossible at the present time to obtain wrought-iron sheets of large dimensions for conduit work. This has necessitated the use in these large mains of steel, and experience up to this time with various coatings for the steel has not been thoroughly satisfactory. This subject is beyond the limits of this paper, but it is interesting to note that experiments are now being made by the city of New York, and perhaps in other quarters, upon the feasibility of lining and encasing large steel conduits with a cement coating, in substitution for the different paints and materials used heretofore for coating steel conduits.

These latter-day developments, however, contemplate a use of the cement coating primarily for the purpose of preserving the metal rather than for securing watertightness, and the results will be watched with great interest.

Relative Cost of Cement-Lined and Cast-Iron Pipe.

In Table XI. is presented a statement of the comparative cost of cement-lined and cast-iron pipe lines. The cast-iron pipe has been figured upon the approximate ruling average price of cast-iron pipe during the last 25 or 30 years, to wit, $25 per 2,000 lbs. The weight of pipe used is that of the New England Water-Works Association standard Class A up to and including pipes of 8 ins. in diameter, and Class B for pipes of from 10 to 24 ins. in diameter. While these classes are somewhat lighter than have been used in city work, they certainly afford a much higher factor of safety than that ordinarily employed in designing cement-lined pipe, and they have been successfully used in many water-works for pressures up to and even in excess of 100 (to 125) lbs. per sq. in. The total cost per foot of the cast-iron pipe furnished and laid is shown in Column 6, and for convenience there is shown in Column 7 the amount which should be added to make a comparison with Class C pipe of the New England Water-Works Association.

The prices quoted for the wrought-iron cement-lined pipe in the case of the Plymouth works represent the actual cost of the pipe, exclusive of administration expenses of the department, and in the other cases the contract prices at which these pipes were laid. It is hoped that others who have used pipe of this character will contribute items of cost for comparison with Table XI.

In general, it may be said that upon the assumed basis of cost of cast-iron pipe, $25 per ton, and the assumed classification, wrought-iron cement-lined pipe does not show any material saving in cost over cast-iron pipe, even when correction is made for the difference in carrying capacity between old cast-iron pipe and cement-lined pipe as referred to previously herein. The latter fact increases the total cost of the cast-iron pipe approximately 7% above the figures shown in Column 6 of the table, as appears from Table XII.

If the ratio in carrying capacities of the cement-lined cast-iron pipe should be as 110 to 100, as has been found to be the case in some cement-lined supply mains, instead of as 120 to 100 as assumed above, the increase in diameter of pipe would be approximately 4% instead of 10%, and the corresponding increase in total cost of pipe line in place approximately 3% instead of 7%, and if the ratio should fall to 90 and 95 there would be no material difference in cost.

Necessary Price of Cast-Iron Pipe to Make Cost of Cast-Iron Pipe Line Equal to the Cost of Cement-Lined Pipe Line.

Data are lacking upon which to base a satisfactory estimate of the price per ton at which cast-iron pipe may be bought without making the cast-iron pipe line more expensive than one built of cement-lined pipe, even with due allowance for greater loss in carrying capacity with lapse of time. It seems probable, however, that this price must exceed $27 to $30 per ton of 2,000 lbs., and still

TABLE IX.—STATISTICS RELATIVE TO THE USE OF CEMENT-LINED MAIN PIPE.
(Compiled from interviews and from reports. Some figures necessarily approximate only.)

City or town.	Population. in 1905.	Works built.	Length of C. L. pipe in miles. 1886.	1906.	Total miles extension 1886-1906.	Extensions of C.L. abandoned.	Replacement begun.	Reason given for abandonment.	Approx. age of pipe when replacement began.	Pressure lbs. per sq. in.	Average annual cost of making repairs per mile of C. L. pipe.	Trouble from Lightning.
Attleboro, Mass....	12,702	1873	16	None	About 36	1880	1898	Trouble making connections	25 yrs.	65-100	.....	1 accident.
Arlington, Mass....	9,668	1872	About 12	4	.....	1872	About 1895	.....	23 yrs.	50-90	.....	2 accidents; 1 cost $974.
Brockton, Mass.....	47,494	1880	3	3	60	....	....	.....	.....	50	.....	....
Beverly, Mass.....	15,223	1869	48	32	Over 19	1894	About 1895	Poor condition of old pipe	26 yrs.	72	$49.00 (1899-1906)	3,000 ft. required replacement.
Burlington, Vt.....	18,640*	1867	19	4	11	....	....	....	?	70-85	.....	....
Chelsea, Mass.....	37,280	1867	23	None	..	1875	1875	Leaks caused by making connections	8 yrs.	50-75	.....	1 accident.
Concord, Mass.....	5,421	1874	21	21	12	1888	Not begun	.....	.....	.....	$5.00	Some trouble.
Concord, N. H.....	19,632*	1872	Over 30	18	34	1887	1898	Breaks from rust	26 yrs.	45-75	$18.00 (1900-06)	400 ft. replaced.
Fitchburg, Mass....	33,021	1873	17	None	40	1877	1883	....	10 yrs.	75-165	.....	....
Gloucester, Mass...	26,010	1884	..	19	..	1896	1896	Poor condition	12 yrs.	15-75	.....	Considerable trouble.
Hartford, Conn.....	79,850*	1857	15	3	..	1884	1886	Frequent breaks; expense of repairs	29 yrs.	.....	.....	....
Lee, Mass.	3,972	1888	10	10	..	1883	Not begun	.....	.....	.....	$20.00 about	1892 damaged 2,000 ft.
Lynn, Mass.	....	1871	63	32	30	1884	1890	....	19 yrs.	.....	....	....
Malden, Mass.....	38,037	1870	About 45	20	35	1890	1892	....	22 yrs.	65	$30.00 about	Considerable.
Manchester, N. H..	56,987*	1872	27	4	62	1877	1877	Trouble in making repairs	5 yrs.	60	.....	1 accident.
New London, Conn.	17,548*	1871	22	About 8	30	1889	1889	....	18 yrs.	60-75	.....	1 stroke caused damage $940.
Pittsfield, Mass....	25,001	1855	3	None	..	....	....	Freezing. Poor workmanship	?	.....	.....	Some trouble.
Plymouth, Mass.†...	11,119	1885	23	47	24	‡	....	....	.....	50	$11.00 (1902-06)	....
Revere and Saugus.	12,650 / 6,253	1884	About 18	18	..	1894	Not begun	Lessened cost of cast iron	.....	70	.....	1 accident.
Springfield, Mass...	73,540	1864	48	33	80	1882	1886	....	22 yrs.	30-120	$10.00 (1900-06)	....
Waltham, Mass....	26,282	1872	20	1	21	1887	1887	Leaks in joints, trouble in making connections	15 yrs.	50-70	$17.00 (1883-91)	1,400 ft. replaced; 4 accidents.
Watertown, Mass..	11,202	1884	14	13	..	1890	Not begun	Cement pipe could not be obtained; trouble from electrolysis	13 yrs.	.....	.....	....
Whitman, Mass....	6,521	1883	12	12	12	1883	Not begun	No appliances for making C. L.; C. I. more convenient	.....	65	Very small	None.
Woburn, Mass....	14,402	1873	39	51	18	1899	Not begun	Lightning, rust, bad joints, thin lining	.....	70-75	$14.00 (1891-06)	200 leaks; 5,000 ft. replaced.
Worcester, Mass...	128,135	1845	41	None	97	1880	About 1880	....	35 yrs.	70-150	$52.00 (1884-86)	....

*1900. ‡Still in use. †Since 1900, Phippe patent.

TABLE XI.—COMPARATIVE COST OF WROUGHT-IRON CEMENT-LINED AND CAST-IRON PIPE LINES.

	With Cast-Iron Pipe at $25 per 2,000 lbs.							With Wrought-Iron Cement-Lined Pipe.					
	Cost per foot.							Costs per foot.					
Internal Diameter, ins.	N.E. W.W.A Class	Assumed weight.*	Pipe cost.	Assumed Cost of laying.	For Class C Total.	pipe add per ft.	Pipe.	Plymouth, Mass.,† 1900-1907. Laying.	Total.	Pa. 1888. Total.	Greensburg, 1873.	Concord, Mass.	Portland, Me.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)		(13)
2	A	17	$0.21	$0.25	$0.46	$0.01	$0.33	$0.30	$0.63	$0.51	$0.76		.....
4	A	28	0.35	0.27	0.62	0.02	0.38	0.45	0.83	0.66	1.02		.....
6	A	40	0.50	0.30	0.80	0.06	0.50	0.50	1.00	0.92	1.22		.....
8	A	57	0.71	0.34	1.05	0.05	0.66	0.77	1.43	1.17	1.57		.....
10	B	72	0.90	0.40	1.30	0.06	0.89	0.79	1.68	1.53	...		.....
12	B	91	1.14	0.45	1.59	0.08	1.13	0.43	1.56	1.85	...		.....
14	B	110	1.38	0.51	1.89	0.10	1.24	0.88	2.12	1.80	...		.....
16	B	129	1.62	0.58	2.20	0.14	1.41	0.83	2.24	...	...		.....
18	B	140	1.86	0.64	2.50	0.16	...	...	...	...	...		.....
20	B	140	1.86	0.64	2.50	0.16	...	...	...	...	...		.....
24	B	195	2.44	0.80	3.24	0.27	...	...	...	...	...		$2.36‡
26	..	...	....	....	....	....	...	...	...	...	...		3.87‡

*Allowing excess weight of approximately 2%.
†Plymouth labor, $2.00 for eight hours.
‡$3.02 equivalent 1908 price.
§$4.37 equivalent 1908 price.

leave the balance as regards reliability in favor of cast-iron pipe; while the average price of cast-iron pipe during the past twenty-five years more or less has been approximately $25 per ton.

Summary of Conclusions.

With due allowance for variation in individual cases, and the local conditions or circumstances surrounding them, the following conclusions seem justified:

(1) *Advantages of cement-lined pipe as compared with cast-iron pipe.*

(a) Freedom from tuberculation and resulting maintenance of carrying capacity.

(b) Carrying capacity probably approximately that of cast-iron pipe 15 to 25 years old. The coefficient of discharge to be used in the Hazen and Williams formula probably lies between $c = 100$ and $c = 120$, depending upon the care used in making the pipe and the excellence of its finish.

(c) Longevity and durability under favorable circumstances.

(d) The cost may show some advantage when cast-iron pipe reaches a price upwards of $27 to $30 per ton.

(2) *Disadvantages of cement-lined pipe as compared with cast-iron pipe.*

(a) Absolutely and relatively greater dependence upon good material and good work in all details of manufacture and laying of pipe.

(b) Greater danger of bad or slipshod work in wet trenches and under conditions affording insecure foundations.

(c) Greater cost under average market conditions.

(d) Unreliability and danger from subsequent excavations adjacent to pipe line.

(e) Small factor of safety and consequent danger from water hammer, careless manipulation of gates, etc. (The usual factor of safety of wrought-iron cement-lined pipes has been from 3 to 4; in steel pipes from 4 to 5, and in cast-iron pipes from 12 to 15, but the greater ductility of wrought-iron or steel as compared with cast-iron should be borne in mind in this comparison.)

(f) Resulting comparatively low limit of safe pressures, 65 lbs. per sq. in., more or less

(g) The carrying capacity may not differ materially from that of old cast-iron pipe if the cement-lined pipe is badly made or laid, or is considerably smaller in actual than in nominal internal diameter.

(h) Danger from lightning and liability of more extended damage from it.

(i) Difficulty in making watertight joints and connections.

(j) Repairs not so easily, cheaply, quickly, or effectively made as for cast-iron pipe.

(k) Difficulty in making service pipe connections and greater likelihood of leakage.

(3) Satisfactory data are lacking upon the carrying capacity of cement-lined pipes. It is believed that under favorable conditions the coefficient of discharge to be used in the Hazen and Williams formula is about $c = 120$, but under actual conditions this coefficient has been found, in several carefully observed cases, to lie between 95 and 110. Unless the conditions are definitely known, therefore, the use of a coefficient not exceeding $c = 100$ to $c = 110$ in the Hazen and Williams formula is recommended.

(4) The relative carrying capacity of wrought-iron cement-lined pipe, new cast-iron pipe, and old cast-iron pipe, based upon assumed coefficients of discharge (for use in the Hazen and Williams formula) is in proportion to these coefficients of discharge:

$c = 120$ for wrought-iron cement-lined pipe (a safer figure would be $c = 100$-110).
$c = 130$ for new cast-iron pipe.
$c = 100$ for old cast-iron pipe.

(5) The comparative frictional losses based upon these assumptions are shown in Table X.

(6) Upon the above assumptions the necessary increase in diameter of a cast-iron pipe line over that of a wrought-iron cement-lined pipe line, that it may have the same discharging capacity at the end of a period of 25 years, more or less, should be approximately 10%. If, however, the relative coefficients of discharge for cement-lined pipe, as compared with cast-iron pipe, are as 110 to 100 instead of 120 to 100, the necessary increase in diameter would be approximately 4%.

(7) The additional cost involved by the above-mentioned necessary increase in diameter of cast-iron pipe over cement-lined pipe, that they may have the same carrying capacity after a long period of years (based upon assumed relative coefficients of 120 for cement-lined and 100 for old cast-iron pipe), is approximately 7%. If, however, the relative coefficients are as 110 to 100, the increase in cost would be but 3%.

(8) The cost of wrought-iron cement-lined pipes as compared with cast-iron pipe does not appear to be materially different and is slightly in favor of the cast-iron pipe up to diameters of 20 ins., more or less—if a comparison be made upon the basis of use of classes A and B, Standard Specifications for Cast-Iron Pipe of the New England Water Works Association, which in the opinion of the writer is certainly as reliable as, and probably more reliable than, wrought-iron cement-lined pipe of the type heretofore used.

(9) For purposes of comparison it seems reasonable to use an average price for cast-iron pipe of $25 per net ton of 2,000 lbs., inasmuch as this figure seems to approximate the average cost of cast-iron pipe for a period of twenty-five or more years in the past.

(10) While it is true that many wrought-iron cement-lined pipe systems, built between the years 1870 and 1880 or thereabouts, are still in use, general experience seems to show that abandonment has begun within a period of 20 or 25 years after construction, though it is probably fair to say that this abandonment may have been due in some measure to the gradual increase in water pressures demanded of our water-works by the change in height of buildings and the improved standards required for fire protection. Certainly the general use of cement-lined pipe for water-works purposes has been given up.

(11) The average annual cost of making repairs to wrought-iron cement-lined pipe appears to have been as low as $10 per mile of pipe under favorable circumstances, and as high as $50 per mile of pipe, or even more, under less favorable circumstances.

(12) Damage from lightning appears to have been a source of considerable expense in making repairs. The cost of these repairs is covered, however, in the above figures of annual cost of repairs per mile of pipe.

TABLE XII.—PERCENTAGE TO BE ADDED TO THE TOTAL COST OF CAST-IRON PIPE (FURNISHED AND LAID) TO COMPENSATE FOR THE ASSUMED DIFFERENCE IN CARRYING CAPACITY BETWEEN CEMENT-LINED PIPE AND OLD CAST-IRON PIPE.

Diameter pipes, ins.	Pipe cost per ft.	Total cost per ft.	Add 10 per cent. to Col. 2.	Resulting total cost per ft.	Increase in total cost, per cent.
(1)	(2)	(3)	(4)	(5)	(6)
8	$0.50	$0.80	$0.05	$0.85	5.9
12	0.90	1.30	0.09	1.39	6.9
16	1.38	1.89	0.14	2.03	7.4
20	1.86	2.60	0.19	2.69	7.6

Say, 7.0

General Conclusions.

In conclusion, therefore, the writer is of the opinion that broadly speaking, it may fairly be said that:

(1) Experience in this country with wrought-iron cement-lined pipe systems *for distribution purposes* has in general been adverse and has led to its replacement with cast-iron pipe—except, perhaps, under conditions where the pressure does not materially exceed 65 lbs. per sq. in., and where there has been but little disturbance of the ground adjacent to the pipe trench which might cause settlement or other injury to the pipe line.

(2) Experience in this country with wrought-iron cement-lined pipe systems *for supply mains* has been much more satisfactory than for pipe distribution systems, and many old wrought-iron cement-lined supply mains are still in active use and giving satisfactory and economical service, particularly under such conditions as are usual in the case of these supply mains—light pressure, secure foundation, and private rights of way within which the pipes are located, resulting in little danger of disturbance.

(3) It is still possible that economical means will hereafter be developed for lining steel or even cast-iron pipe in a similar manner so that so successfully now employed in lining service pipes with cement, which will result in a better pipe than any yet used. But such use of cement is likely to be limited to furnishing a durable coating rather than watertightness and added strength to the pipe.

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THE LOWER YELLOWSTONE IRRIGATION PROject, Montana-North Dakota, has been completed by the U. S. Reclamation Service. Water for irrigating 45,000 acres will be available during the season of 1909. This is the second government project carried out on the Yellowstone. Charges for water rights under this project have been fixed at a total of $42.50 per acre of irrigable land, payable in annual instalments of $4.25 per acre or some multiple thereof, without interest. This provision pays for construction costs, only. In addition, there will be an annual charge for operation and maintenance, which, until further notice, will be $1 per acre. Water-right applications are filed at either Miles City, Mont., or Williston, N. Dak. All applicants for water rights must join the Lower Yellowstone Water Users' Association. This association, like those organized on other projects, enters into a contract with the U. S. Government, guaranteeing the payment of the water-right charges by the members of the association, and the members in turn give the association a lien on their land.

THE AVERAGE WAGE OF WORKMEN at Sheffield, England, employed on highways, sewers, tramways, and at the sewage works, parks and recreation grounds, was $4.86, $5.33 and $5.51 per week in 1905-06, 1906-07 and 1907-08, respectively. In the year 1907-08 the highest number of employees on these various classes of work was 2,900, on March 18, and the lowest number 1,569, on Jan. 1. The average for the year was 1,812, and the total wages paid these men amounted to about $519,000. Payments for "team work" in 1907-08 were about $86,000, as compared with about $64,000 in each of the two preceding years. Some interesting comments on the terms of employment of these workmen may be quoted here from the annual report of Mr. Charles F. Wike, M. Inst. C. E., City Engineer, for the year 1907-08, from which the above figures have also been taken:

During the year great attention has been paid to the question of giving the men permanent employment, and a system of transfer from one district to another has been brought into operation. The result of this has been that very little time has been lost, except through stress of weather, and it will be noticed that the average wage per man is somewhat higher than was previously the case, notwithstanding that during the latter part of the year a considerable number of relief men were employed. These men, as a rule, do not earn as good wages as the ordinary workman, and the fact that they have been employed tends to lower the average.

During the year the whole of the regular employees were, for the first time, allowed one week's holiday. The number who benefited by the new regulation was 1,171, and the cost of the holiday £1,530 10s. 0d. [about $7,500]. The number for the coming year is likely to be considerably larger.

There is no doubt that this innovation, together with the increase of wages given in January, 1906, has greatly increased the competition for permanent employment under the Department. The increase referred to was one of a half-penny per hour to the great body of laborers, including both unskilled men and those who were engaged upon special work, such as timbering, pipe-laying, asphalting, floating, etc.

The number of men to whom the advance had been granted to March 25 last was 678, and the additional annual cost to the Department was estimated at £3,619 [about $18,000].

The estimated population of Sheffield, as given by the "Municipal Year Book" for 1908, is 456,000, and its area is 23,062 acres.

Concrete Water Tank Support and Signal House at Waterbury, Conn.

The accompanying half-tones show two different types of reinforced-concrete construction which have been recently completed by the New York, New Haven & Hartford R. R. in the new station work at Waterbury, Conn. Fig. 1 is a support for a water-tank just across from the new station, which may be seen in the background of the view. The construction of the support is evident from the cut. It is 30 ft. 9 ins. wide and 40 ft. high, and is designed to carry a 55,000 gal. wooden tank. The reinforcement of each post consists of two 95-lb. rails, placed back to back and riveted every 3 ft. and in the platform ½ in., corrugated bars are spaced 4 ins. on center. In the signal tower, which is built with reinforced-concrete walls, there is installed a 64-lever machine for the operation of signals and switch connections. The work was designed by the engineers of the railway and built by the O'Brien Construction Co., of Waterbury.

Fig. 1. Water-Tank Support at Waterbury, Conn. (Built for the N. Y., N. H. & H. R. R. by the O'Brien Construction Co.)

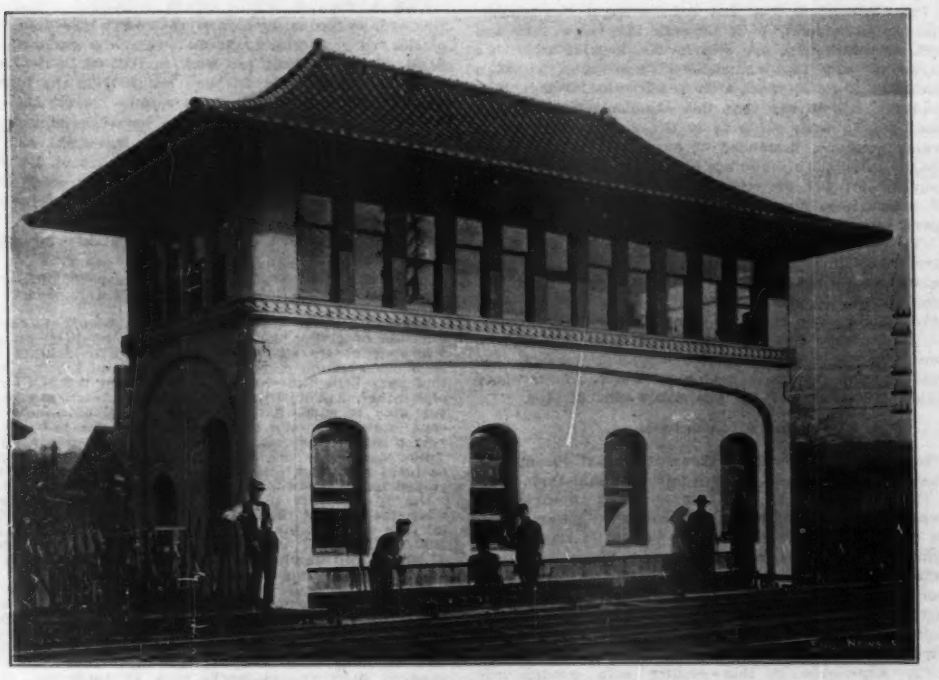


FIG. 2. REINFORCED-CONCRETE SIGNAL HOUSE.

A Recommendation for Concrete, Plain or Reinforced, for All Bridges of 50-Ft. Span or Less in Illinois.*

No matter what the character of the road, it is necessary to have bridges that will sustain the loads that come upon them, and the bridge on the sparsely traveled road may have quite as heavy a load come upon it as the bridge upon the much more traveled road, so that the bridge requirements are more nearly the same for all localities than is the case with the character of the road surface.

Particular mention is made of the small span bridges, because they constitute by far the largest proportion of the bridges and at present require much the greater amount of money for their maintenance. Practically all of the bridge money spent to-day is really for bridge maintenance rather than for the construction of new bridges, including under maintenance renewals of bridges which have become useless. If, therefore, some plan could be devised by which this present constant maintenance expense could be avoided, it should receive earnest and immediate attention.

After a careful study and actual experience with conditions in all parts of the State, it is recommended that all bridges of 50-ft. span or less should be constructed of concrete or reinforced concrete, as this is the most permanent form of construction known to engineers to-day.

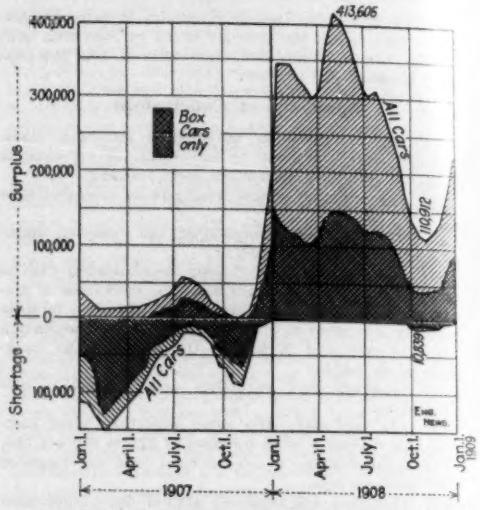
The plan proposed is for a township to have a careful inspection made of all bridges and the required sizes noted and listed. There would be found, for instance, to be a certain number of 8-ft. openings, a certain number of 10-ft. openings, and so on. Plans for the various sized bridges could then be made and the total amount of work necessary and the estimated cost ascertained. The township would then undertake to build all of these bridges within one or two years, securing the necessary funds by issuing bonds for the required amounts. The work could be let in one contract of sufficient magnitude to secure keen competition, and from the fact that many bridges would be duplicated, a contractor could undertake the work at a much lower figure than would be possible if the bridges were contracted at different times.

The result would be the canceling of the greater portion of the bridge tax that the townships are now called upon to pay and the money now apportioned for bridge maintenance would in most cases be ample to pay the interest and sinking funds on the bonds. From the fact that the structures that would be built are of such a permanent character, it is in every way just that the cost should be distributed over a number of years and would entirely justify bonds running for at least twenty-five years. Such a plan, however, should not be undertaken without certain limitations, to insure, first, the proper design of these bridges and, second, their proper construction. Such additional legislation as might be necessary to make this plan effective should require that all plans for this work should be approved by the State and the work carried on under State specifications. This would be necessary to safeguard and secure to the taxpayers the standard of design and construction that work of this character requires and public safety demands.

*From Report of the Illinois Highway Commission for 1907; A. N. Johnson, Assoc. M. Am. Soc. C. E., State Highway Engineer, Springfield, Ill.

Two Years of Freight Car Service.

The latest bulletin of the Car Efficiency Committee of the American Railway Association brings the records down to the end of 1908, the last fortnightly report being for Dec. 23. It shows on the latter date a total of 222,077 idle cars (excluding cars in shop), which represents an increase of 46,500 in two weeks, of which only



Freight-Car Shortage and Supplies in 1907 and 1908. (For 160 Railways of the United States and Canada; from the reports of the Car Efficiency Committee, American Railway Association.)

2,500 cars are due to a decrease of cars in shop, so that 44,000 road cars became idle. This increase is about equally divided between box cars and coal, gondola and hopper cars (about 20,000 each).

The entire record for 1907 and 1908 is shown by the curves herewith. They show that the period of congestion or car shortage continued to within a few weeks of the end of 1907, while 1908 has been a year of consistent surplusage. The maximum of idle cars, in May, exceeded 400,000 nominal, or, as in this period, the normal number of cars in shop (about 100,000) was more than doubled, the real surplus exceeded 500,000 cars. Since that time there has been a steady decrease in shop cars, down to nearly normal conditions.

The number of idle road cars decreased sharply in the late summer, to a minimum of 110,000 at the beginning of November. There has been a rapid increase since then to the present total of 222,000 cars, representing close to 10% of the total number of freight cars in the United States and Canada.

GROWING TIE TIMBER on its right of way is reported as being under trial by the Louisville & Nashville Ry., on the St. Louis Division in the State of Illinois. The reports state that catalpa trees are set about 18 ft. apart and that they are under the care of the section gangs.

WAVE MOTOR INVENTIONS are again being experimented with on both sides of the continent. At Atlantic City two revolving wheels are being put in place at Young's Pier. The apparatus is the invention of Mr. William Snee, of Pittsburg. It is described as consisting of an upright cylindrical wheel equipped with vertical parallel blades revolving within a stationary shield. This outside shield contains deflectors, or guides, which direct the entering currents of water against the vanes of the wheel. The two wheels now being installed are said to have a total weight of 61 tons and are supported on a concrete pile structure.

On the opposite side of the continent, at Long Beach, Cal., a wave motor patented by Dr. C. A. Burrows has been built. A large float is secured to a pile framework, and the motion of the float by the waves is utilized to drive machinery.

Revision of Line of the Kanawha & Michigan Ry.; With Unit Costs of the Work.

By J. A. STOCKER.*

The Kanawha & Michigan Ry., which is the southern division of the Ohio Central Lines, extends from Corning, O., to Gauley Bridge, W. Va. Through southern Ohio it follows Leading Creek, a very crooked stream which winds in and out between the interlocking spurs of the hills bordering its tortuous valley. The character of the country is such that it was impossible to build a railway at a moderate cost without the use of excessive curvature. The original line contained numerous 8° curves, and in several cases the curvature was greater than this.

Within the last few years, the business of the road has increased very rapidly and at present it is carrying a very heavy coal traffic. With the increase of business, it became necessary to make many revisions of line and grade, and many of the most objectionable curves have been reduced. The standards adopted for all line revisions are as follows: maximum curvature, 3°; maximum grade against northbound traffic, 0.3%; maximum grade against southbound traffic, 0.5%.

There were several miles of very crooked line at Langsville, O., with numerous 8° curves and one long curve of 8° 43'. The operation of this piece of track has been very costly, on account of rapid wear of rails and ties and numerous derailments. Surveys for revision of alinement were made in the spring of 1906, and plans prepared for the revision of two miles of line. Authority was obtained in the summer of 1906 for the rebuilding of the first mile, as shown on Fig. 1. The curve south of Langsville station was not reduced to the standard (3°) on account of the proximity of the creek. The compound curve on bridge No. 470, at the north end, was left undisturbed in anticipation of the rebuilding of another mile of track to the north.

The cut between stations 12,243 and 12,255 (see profile in Fig. 1) was made with the steam shovel, and the excavated material was used to widen fills over a stretch of 30 miles of track. After the contractor had graded sufficiently to enable a loading track to be built on to and over the cut, the railway company took the excavation of the cut into its own hands, using its own steam shovel, unloading plows, and spreader car. The steam shovel was started in November, 1907, and work was continued through the worst winter weather. The material was largely a dry clay, except for a few feet of shale in the bottom at the middle of the cut. The clay broke up into blocks. There was never any trouble from freezing on the cars, even when left loaded over night. After plowing from the flat cars, the spreader car (made at the company's shops) was run along the work and the material pushed over the sides of the fill. Very little hand labor was necessary to keep the track clean. The cut was made and material put on to the old fills at a total cost of 16 cts. per cu. yd.

The excavation of the tunnel approaches was begun in the fall of 1906 and continued through a very wet winter. The material encountered in the hill was largely a hard blue shale; there was a ledge of limestone 3 ft. thick, 15 ft. above subgrade, and a ledge of sandstone just above the tunnel top at the north end. The shale was very hard when blasted, but exposure to the weather soon disintegrated it. There were over 37,000 cu. yds. of excavation in the two approach cuts, which was removed at a cost of $1 per cu. yd.

The air and electric plant installed by the contractor for the excavation of tunnel and approaches was as follows: One 80-HP. Atlas boiler. One Ingersoll-Rand class A steam-driven air compressor (steam cylinder 16¼ × 18 ins., air cylinder 16 × 18 ins., running at 120 r. p. m., furnishing 498 cu. ft. of air per minute at 100 lbs. pressure). One air receiver 3½ × 8 ft. with safety valve. A 3-in. main pipe line from compressor over the hill to farther portal of tunnel, with a branch to the near portal. Water trap in pipe line. Six 14-in. model D-5 Little Giant rock drills, and one E-24 rock drill. Five tripods and two tunnel columns for drills. Air hose for connecting drills to air main (1-in. 9-ply linen fabric wire-wound hose). Fitted drill steel up to 16 ft. in length. Four sand pumps. One 6-KW. 110-volt dynamo for electric lighting. A Clark automatic horizontal 10-HP. steam engine to run the dynamo. Lights and wiring for all parts of the tunnel and approaches. The total cost of air and electric plant (less freight) was $6,665.

The excavated material was handled in dump cars drawn by horses and running on steel rails.

Tunneling was begun in the spring of 1907. The tunnel is 712.7 ft. long, face to face of portals, with 17 ft. 8 ins. lateral clearance and 22 ft. vertical clearance above top of rail. The heading, which included everything above the plumb post caps (see Fig. 2) was driven from both sides of the hill and the timber arch put in as the work progressed, using the cap as a temporary sill. The shale was firm enough to permit the excavation to be carried from 6 ft. to 8 ft. ahead of the timbering without danger. Great care was exercised in backfilling behind the lagging, especially at the arch haunches. The work of taking out the lower bent and setting the plumb posts was kept considerably in the rear of the heading work. The cost of tunneling, including the timber lining in place, was $82 per ft.

The permanent lining consists of a reinforced concrete wall (8 ft. high) on each side, with brick masonry above and brick arch, Fig. 2. The reinforcement of the side walls (Fig. 3) consists of old rails and truss rods from old cars. The rails were set in holes drilled into the bottom of the tunnel and built into the brick walls above, thoroughly tieing the brick work, concrete and tunnel floor together. After the reinforcement and forms were in place, the concrete was mixed in a Smith mixer run by compressed air and mounted on an ordinary flat car. The concrete was dumped directly into the forms for the walls. The material cars were coupled to the mixer car, and the whole moved along as the work progressed. A 1:3:5 mixture of Alma cement, lake sand and ¾-in. to 2½-in. limestone was used. This concrete cost $8.50 per cu. yd. in place, including the forms and reinforcement.

It was the original plan to leave a 2-in. offset where the brick walls were built upon the concrete, in order to support the forms or centering for the brick arch on the top of the concrete sides. That idea was abandoned, however. The brick side walls were built up flush with the concrete sides, and carried about 2 ft. above the

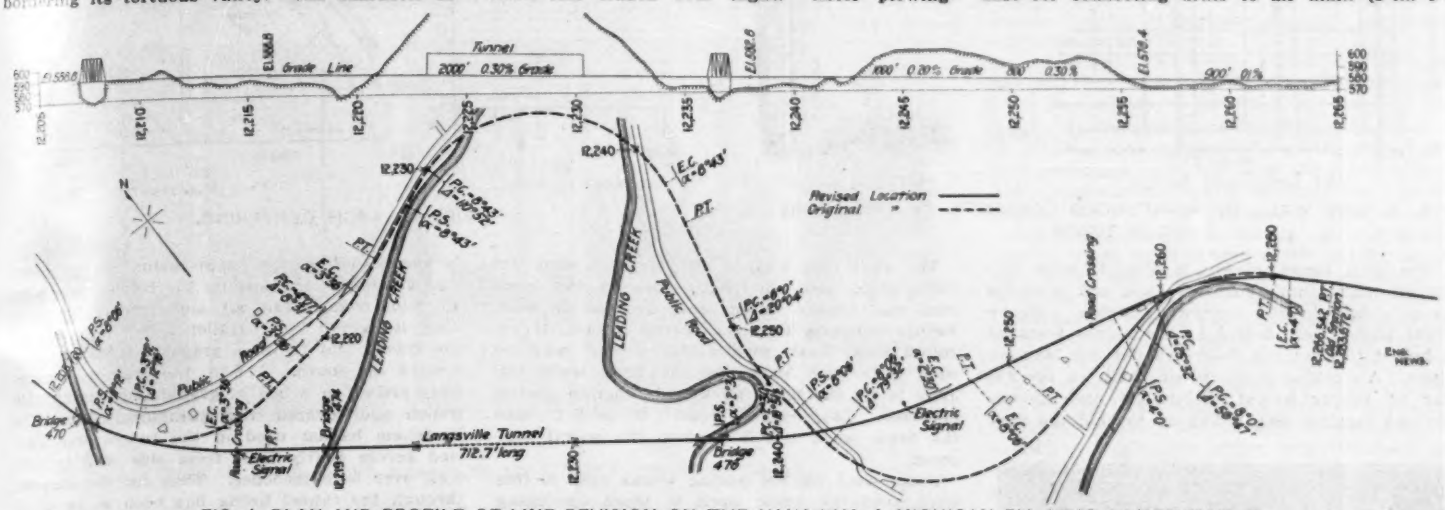


FIG. 1. PLAN AND PROFILE OF LINE REVISION ON THE KANAWHA & MICHIGAN RY. NEAR LANGSVILLE, O.

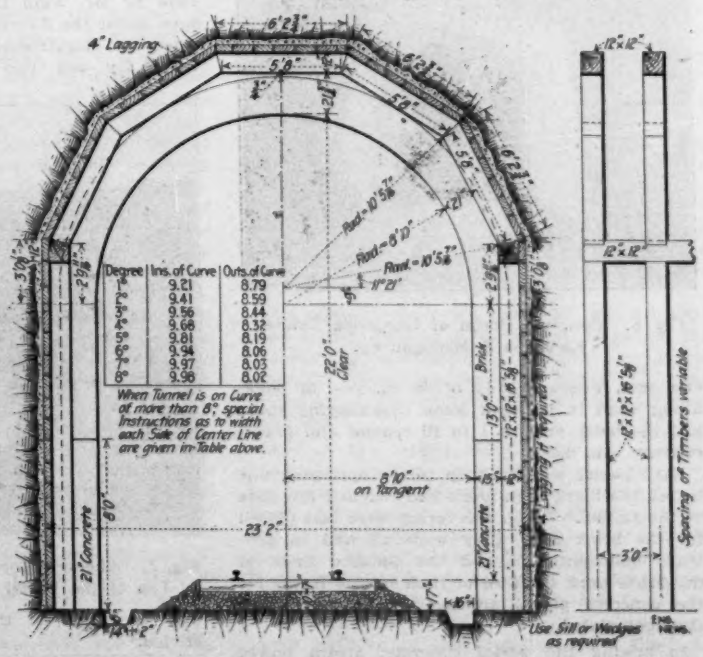

4" Lagging
Degree | Ins. of Curve | Outs. of Curve
1° 9.21 8.79
2° 9.41 8.59
3° 9.56 8.44
4° 9.68 8.32
5° 9.81 8.19
6° 9.94 8.06
7° 9.97 8.03
8° 9.98 8.02
When Tunnel is on Curve of more than 8°, special Instructions as to width each Side of Center Line are given in Table above.
8'10" on Tangent
23'2"
22'0" Clear
21" Concrete
Brick
Spacing of Timbers variable
Use Sill or Wedges as required
Eng. News.

FIG. 2. TIMBERING AND LINING OF THE LANGSVILLE TUNNEL.

*Assistant Engineer of Construction, Hocking Valley Ry., Columbus, O.

springing line of the arch before the forms were placed, the bricklayers offsetting each course of brick above the springing line to conform with the arch.

The bricks used were No. 2 Trimble paving brick, laid in Portland cement mortar with as thin joints as practicable. The harder burned brick were selected for the exposed courses.

terial cars containing brick, sand and cement. The bricks were delivered on to the working platforms by wheelbarrows on inclined runways. The mortar was mixed on the flat car under the forms, and was hoisted by hand to the working platform. A pipe line was laid through the tunnel to furnish the necessary water.

place at a cost (including forms) of $8.18 per cu. yd.

For drainage, 12-in. sewer pipe was laid in both approach cuts to the tunnel, and 6-in. sewer pipe in both sides of the steam shovel cut. The sewer pipe was laid below subgrade and covered with engine ashes. At the portals and at springy places in the cut these drains were

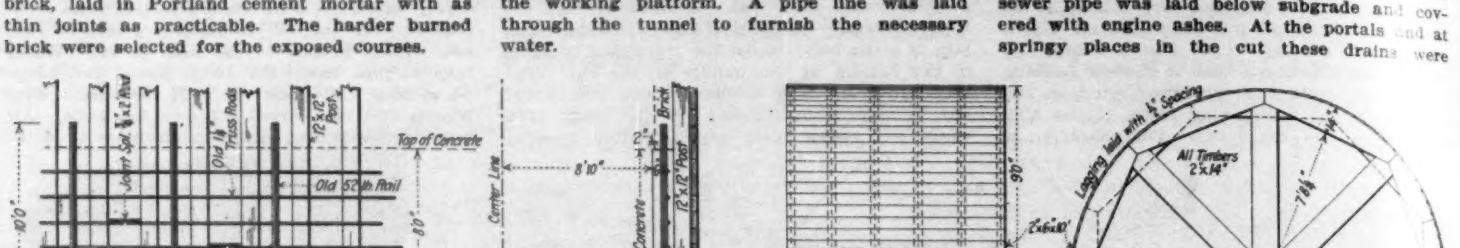


FIG. 3. SIDE WALL OF REINFORCED CONCRETE IN THE LANGSVILLE TUNNEL.

FIG. 4. ARCH CENTERING.

The arch forms, shown in Fig. 4, were furnished with plumb posts at each end reaching to sills laid in the subgrade ditches. Heavy cross pieces were bolted to the plumb posts at a height to clear the floor of a flat car between them. A working platform was built on the flat car at proper height under the arch forms. Enough lagging was spiked on to hold the centers in position, and the remainder was laid on loose as the arch was built.

Fig. 5. Arch Centering at Portal, with Car for Building the Arch.

The arch forms were in two sections, each 14 ft. long measured along the axis of the arch. Both sections were started at the middle of the tunnel and worked from each other toward either end. The rate of progress was 14 ft. per day. That made it necessary to move each section every other day. It was found to be unnecessary to wait for the cement to set after keying, as the process of building was so slow that there was only a small amount of unset mortar left when keying was completed and the surrounding material would safely bridge over. The forms were therefore moved as soon as desired after keying the arch.

The operation of moving a section of forms was as follows: Slight pressure was exerted under the horizontal cross pieces by jacks set on the car floor. The wedges under the plumb posts were loosened. The jacks were lowered several inches, lowering the forms from the finished arch. The car was then pushed ahead the length of the section, the forms were jacked up into place, and the wedges tightened between the plumb posts and sills previously laid to proper grade. Needless to say the track on which the car was run was nicely lined and surfaced or there would have been trouble with the forms binding on the side walls.

Fig. 5 shows the arch forms when in place to serve as forms for the concrete portal. Following the car bearing the forms were the ma-

The arch ring was at all places at least five rows deep, and all spaces between the brick ring and timber lining were bricked in solid. Before reaching the end of the tunnel, 1¼-in. round rods (each with a flat turned hook on each end) were built into the brick walls and arch to tie the brick work and concrete portals together. They extend from 6 ft. to 8 ft. into the brick work and 3 ft. into the portal concrete.

There were 750,000 paving bricks used in this work, and the brick work in place (including forms) cost $27 per 1,000, or $9 per cu. yd.

The portals are of mass concrete with enough iron rods embedded to insure proper bond between the various layers and to avoid temperature cracks. The finished portal is shown in Fig. 6. The materials and proportions were the same as for the side-wall concrete, except that a weaker mixture was used in backfilling. In

Fig. 6. Concrete Portal of Langsville Tunnel; Kanawha & Michigan Ry.

one case, where a body of 30 cu. yds. of backfilling went in between some overhanging rocks and the brick arch, a 1 to 10 cement and gravel mixture was used.

Each portal was built up to the springing line before the brick arch work had reached the ends of the tunnel. When the forms were last placed for the brick arch, they were allowed to protrude sufficiently beyond the finished ends of the brick work to allow of their use as forms for the concrete portal arches. The portals were then completed.

In mixing the portal concrete, steam power was used to run the mixer instead of compressed air. The mixer and engine were mounted on a flat car coupled into a train with the material cars. The concrete was carried to the forms in wheelbarrows. Fig. 7 shows the plant in operation, with runways on trestling on the tops of the cars. The picture was taken when the forms were at full height and the work was almost complete. There were 600 cu. yds. of concrete in portals and backfilling, and it was put in

furnished with brick catch-basins having cast-iron gratings. In finishing the tunnel subgrade, an 8-in. trench was cut along each side wall with its grade line parallel with the grade of the track; that is, on a grade of 0.3% dropping toward the south. A 6-in. tile drain was carefully placed on a bed of granulated slag in this trench and covered with granulated slag. The limestone ballast used in the tunnel was carried across nearly level from side wall to side wall over both trenches. Thus far the seepage through the tunnel lining has been so small as to be negligible. In fact water has appeared at a few places only, and very little at any one place.

Automatic electric signals were installed 800 ft. on either side of the tunnel, to protect trains on the section of track between.

With the exception of a small amount of grading which was done on a yardage basis, the entire work was executed on a force account and percentage basis. All material and supplies were purchased by the railway company's purchasing agent. Talbott & Lindsey, of Middleport, O., were the contractors, but while the work was in progress the partnership was dissolved and the greater part of the work was done by Mr. John D. Lindsey. The work was done under the direction of Mr. Wm. Michel, Engineer of Maintenance of Way of the Hocking Valley Ry. and Ohio Central Lines. The writer

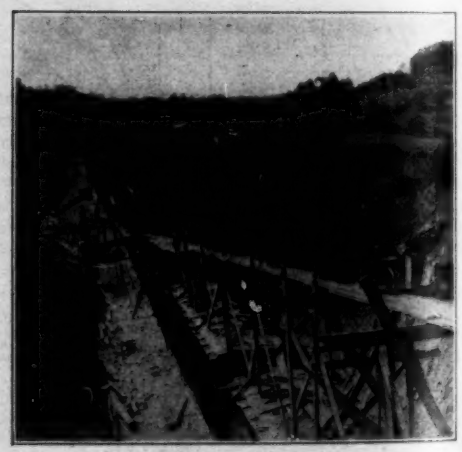


Fig. 7. Wheeling Concrete over Work Train to the Top of the Portal of the Langsville Tunnel.

was in charge of the work, reporting to Mr. Michel.*

*We recapitulate, for convenience, the items of cost of the work described in this article.—Ed.:

Excavation of clay cut (including depositing material on old banks)	$0.16 per cu. yd.
Excavation of shale in tunnel approaches (with rock ledges)	1.00 " " "
Tunneling in shale (including timber lining in place)	82.00 per ft.
Concrete side walls of tunnel (including forms and steel reinforcement)	8.50 per cu. yd.
Brick walls and arch of tunnel (including centering), $27 per 1,000 bricks, or	9.00 per cu. yd.
Concrete in portals and backfilling (including forms)	8.18 per cu. yd.

A Few Notes on American and European Street Lighting.

By H. THURSTON OWENS.*

The results of recent activity in the field of illuminating engineering are being felt in street as well as interior illumination, and it is evident that future installations will show the result of better engineering as well as a more proper regard for the appearance of our streets by day. In the past money seems to have been spent upon posts and fixtures, but that the engineers have failed to agree upon many of the fundamentals of good street lighting would seem evident from the various means adopted.

Fig. 1. Fig. 2. Fig. 3. Fig. 4. Fig. 5.

FIGS. 1. TO 5. FIVE EXAMPLES OF STREET-LAMP FIXTURES.

The data available as to what has been accomplished in this country is very meager in quantity and unsatisfactory in quality. Of the bulletins of the Bureau of the Census, U. S. Department of Commerce and Labor, containing statistics of street lighting, the latest available one is dated September, 1905. In this report all of the cities having 30,000 population or more are included and the figures showing the general conditions are given in Table I.

A comparative analysis of these figures with the number in use in 1901 shows that electric lamps were increasing in use much more rapidly than gas lamps, vapor lamps were about holding their own and, as might be expected, the number of oil lamps were reduced one-half. A number of important changes have taken place since the 1905 report was published, and the writer would give the conditions of to-day briefly in what follows.

At least 25% of the arc lamps are of the old open type, the largest installations being in Chicago and Philadelphia. Owing to the introduction of high-efficiency, incandescent-filament lamps for street lighting, this type of illuminant will show great gains in the future, but up to the present time at least one-half of the electric incandescent lamps are of the old carbon-filament type. Mantle gas lamps are steadily increasing in use but the old open type are still 25% of the total gas lamps in use. Philadelphia alone contributes over 22,000. These are furnished free by the gas company. The last named city redeems herself, however, by having the largest single installation of mantle naphtha lamps (nearly 15,000). At least 50% of the naphtha lamps of the country are of the mantle type, but they will probably not be more numerous owing to the increasing price of oil. The old kerosene oil lamps are a relic of the past and need not be considered. The figures given show that at least 30% of the lamps now in use are of a type entirely obsolete.

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Comparing the conditions here with those abroad we find that on the prominent thoroughfares gas lamps predominate, but the essential difference lies in the fact that a large percentage of the lamps used there are of much higher efficiency and the number of lamps is from two to five times as great. Arc lamps with clear globes are in almost universal use here, while alabaster or opal diffusing globes are the types used abroad. The maximum candle power of old open arc with clear globe is at 40° below the horizontal, and for this reason the lamps were placed about 25 ft. high, whereas in the enclosed type the maximum is much nearer the horizontal, so that the best results are obtained at a height of 18 to 20 ft. The evolution is illustrated in Fig. 1, the old familiar hood has been left upon the pole and the new lamp has been suspended by a bracket. There seems to have been a reason for the place given to both of the lamps used in this case, but this is the exception and not the rule. Leaving the old useless apparatus on the unnecessary length of pole has not contributed to the beauty of the location.

In the case shown in Fig. 2 the idea appears to have been to bring the lamp over the corner, where it belongs, but more sightly apparatus would have been preferable for a permanent location.

The indiscriminate use of mast arms has been one of the worst features of arc lighting, as they have often brought the light too far below the upper limit of ordinary vision. Where the streets are lined with trees their use becomes a necessity, but owing to the ease with which the lamps can be cleaned and trimmed, the long mast arm is often used whether there are trees or not.

The matter of trimming has been provided for in the fixture shown in Fig. 3 by means of a swing-joint, and although the appearance leaves much to be desired, it is an improvement over the one shown in Fig. 2.

The fixtures described thus far are all supplied from overhead circuits and represent the majority of installations. Among the larger cities the conditions are quite different, owing to the great developments in underground construction.

One of the recent installations on a street lined with trees is shown in Fig. 4, where arcs are being erected and gas lamps removed on account of the heavy traffic. The efforts to introduce high-pressure gas lighting in this country have not been successful, there being only one small installation of this kind at the present writing. This illustration shows the latest developments in both mantle gas and electric arc street lighting in this country. The gas-lamp post is a one-piece casting suitably ornamented, and arranged to bring the burner about 12 ft. above the street. The arc-lamp post is a steel shaft with outer ornamental casting of cast iron. The lamp in this case is 20 ft. high and 12 ft. out from the curb and is enclosed in an alabaster globe.

Where arc lamps have displaced gas abroad, the flaming type has been used, but on account of the intense glare and the fact that nearly all of the light is thrown immediately below, it is necessary to place the lamps from 30 to 40 ft. high. Those installed in London are hung upon wires strung from the buildings 30 ft. above the street, while in Germany handsome poles have been used, usually exceeding even this height. (See Fig. 5.) This does not seem to the writer a sensible procedure for street lighting, for the lamps can be readily equipped with some type of diffusing and distributing globes which can be so arranged as to cut down the intrinsic brilliancy and also distribute the light over a wider angle.

The reason why gas lamps are not used in this country upon those streets where a high intensity is necessary is because only low pressure is generally available for use with upright mantles, whereas abroad gas is displacing electricity by means of high pressure distribution and inverted-mantle burners. The high-pressure system in use in Berlin is one of the most successful, the gas being supplied through Mannesmann steel pipe under 2 lbs., or approximately 60 ins. pressure. The lamps in this case, however, are of the type known in this country as inverted gas arcs, being arranged for two or three burners, and especially designed to meet competition from the electric flaming arc. In a paper before the last meeting of the German Gas Association Prof. Diehschmidt stated "that the three-burner lamp consuming 85 cu. ft. of gas per hour gave 3,441 mean lower hemispherical c. p., or about 40 c. p. per cu. ft. of gas." Similar lamps under low pressure and used for indoor lighting in this country when equipped with five mantles have a mean lower hemispherical c. p. of 412 when consuming 15 cu. ft. of gas per hour, or 27.4 mean lower hemispherical c. p. per ft. Other high-pressure systems are in use where the air is compressed, and in one case pure oxygen is supplied to the burner. Still another type known as the self-intensifying, is in successful use in London. In this type the air is compressed by utilizing the heat of the products of combustion to operate a heat engine. The lamps consume 17.5 cu. ft. of gas per hour and give 500 mean lower hemispherical c. p., or 37.0 c. p. per ft.,

Fig. 6. An Ornamental Street-lamp Fixture with Unattractive Neighbors.

TABLE I.—STREET LIGHTING CONDITIONS IN 1905 IN THE CITIES OF THE UNITED STATES HAVING OVER 30,000 POPULATION.

Kinds of Lamps.	Electric		Gas				
	Arc.	Incand.	Welsbach.	Other.	Vapor.	Oil.	Total.
Total No. in use	140,044	32,996	119,812	71,977	47,012	2,425	414,266
No. of cities using various types	154	62	45	28	31	12	....
No. of lights per 10,000 population	63.1	14.9	54.0	32.4	21.2	1.1	....
No. of lights per 100 miles of improved and unimproved streets	329.9	77.7	282.2	169.6	110.7	5.7	....
Percentage of No. in use	34	8	29	17	11	0.6	....

the burner being upright. The tests reported in this case include the candle power and the B. T. U. ratings of the gas used as 16.53 and 616 respectively.

When comparisons are made as to the efficiency of gas lamps of the mantle type it is highly important to know what kind of gas is used, as otherwise the results will often be very misleading.

Another departure from American methods is that of automatic lighting and extinguishing, and this is divided into two classes, pressure-wave and clock-control. Pilot lights are used in both cases; in the former the lamp cock is operated by means of a sudden increase in pressure of about 0.8 in., say from 2.5 to 3.3, and lasts either several seconds or several minutes, according to the type used. In one style of cock operation an electric spark is generated so that the expense of the pilot light is eliminated. The saving is not confined to labor, for the mantles last much longer.

In Paris low-pressure gas lighting still maintains its supremacy, but the conditions to be found there are hardly comparable with any American city owing to the great number of trees. The gas lamps have been supplied in such profusion and they are so pleasing in appearance that they are in every sense successful. Where additional light is needed arc lamps with dense diffusing globes are used, but the number of gas units is not reduced.

FIG. 7. A VIENNA PARK LOCATION WITH ARCS ABOVE THE TREES AND GAS LAMPS BELOW.

The newest installation of low-pressure lamps abroad which is particularly noteworthy is that of Edinburgh, where inverted lamps were selected which consume only 2.5 cu. ft. of gas per hr., as against 3.5 cu. ft., the standard in the United States for upright burners. The use of mantle gas lamps for lighting residence streets is one of the best features of our street lighting, the only criticism is on their infrequent spacing. When 60-c. p. lamps are located more than 125 ft. apart the whole idea of effective lighting is lost, as the minimum illumination is a negligible quantity.

When one considers the expense of installation and maintenance of a street-lighting system it is a waste of money to save a few dollars and thereby defeat the purpose for which the lamps are supplied.

Wherever possible, the lamps should be placed along the curb, and if brackets, such as carry incandescent lamps, are used upon the poles supporting the transmission lines they should usually be placed upon the street side.

Often in this country, arc lamps have been used exclusively for lighting residence streets, especially in the smaller cities, where these are the only street lamps employed, but fortunately it is becoming more generally recognized that, in cities where funds will permit, they may be replaced by lower candle power units, either electric or gas, with improved illumination and enhanced beauty.

Where no trees are to be found it is generally preferable to locate the lamp close to the curb as shown in Fig. 6. The post used is of wood, as the lamps are for series high-voltage circuits, but this reason for the use of the wooden pole does not carry as much weight as formerly, and a more attractive lamp support may usually be employed. This installation is typically marred by other street fixtures; in this case a fire gong which is sounded to herald the approach of fire engines. The street-lamp post can be made most attractive and add greatly to the appearance of a city's streets, but it is apparent that in order to obtain results worth the expense, other street fixtures must also be brought into harmony.

For the best distribution of the light, it is usually important that the lamps should be alternately located upon opposite sides of the street, and this can be readily done where there is underground current distribution.

[In addition to the specific comparisons of street lighting methods given by Mr. Owens in the foregoing article, a few remarks in the nature of remedial measures for exterior lighting faults seem desirable. Where the street lighting is felt to be unsatisfactory, generally rather than specifically, the troubles can often be segregated by a little careful observation and study. The most common trouble, perhaps, is from spacing high-power units long distances apart, resulting in insufficient illumination at intermediate points and blinding glare close to the lamps. The next important trouble might well be attributed to failure to adapt the power and character of illuminants to the environment, and after that comes the employment of fixtures that are eyesores.

A few pertinent suggestions come to mind that may be useful to engineers in smaller places where it is not expedient to engage the services of a specialist for the improvement of the city lighting.

(1) Change open arcs to enclosed. It must be borne in mind that the old commercial rating of open arcs as "2,000-c. p." was a fictitious value, and that in substituting the enclosed lamps, rated in different terms, a 7.5-amp. series alternating-current lamp is considered to give about equivalent service to the 6.6-amp. direct-current lamp (the old "2,000-c. p." type). When "equivalent service" is mentioned the term includes several factors besides the amount of light given off, such as improved distribution, lessened intrinsic brilliancy, lower operating charges, etc.

(2) Locate even the enclosed arcs closer together, even close enough so that additional diffusing globes may be used. This will increase the cost of a given value of illumination, but should result in more pleasing and hygienic lighting generally.

(3) Change the carbon incandescent lamps to tungsten-filament, thereby reducing the cost of a given illumination or increasing the amount of light for the same cost. Investigate the possibilities of using glass or other distributing globes to eliminate the very bright filament and to throw the light where most needed.

(4) Investigate the advisability of replacing open-arc lamps in the more attractive residential streets by a greater number of small candle-power enclosed arcs, or by incandescent-filament lamps.

(5) Replace the open-flame lamps—gas, vapor and oil burners—by mantle-lamps, giving more adequate illumination for equal cost.

(6) Install lamp supports that are pleasing to the eye, bearing in mind that beauty in such construction does not necessarily mean elaborate ornamentation. It is often advisable for an engineer to call upon local architects and artists for advice. These men usually have sufficient civic pride to gladly cooperate and to donate their services to such a worthy end. Seek to have ramshackle and ugly street fixtures generally replaced.—Ed.]

Report of the New Jersey State Water-Supply Commission.*

The State Water-Supply Commission of New Jersey was created a year or two ago to have control of the distribution and use of potable waters of the state. This control includes the approval or disapproval of all new or additional water supplies involving the taking of surface waters and the determination of the revenue to be paid the state for all surface waters diverted above 100 gals. per capita. The commission also has certain duties relating to water storage for conservation and flood prevention. The following particulars regarding the work of the commission during 1908 and the problems now confronting it are taken from the annual report just submitted to Governor Fort.

The first part of the report deals with the Passaic River storage scheme, which the present commission has inherited from the old Passaic Flood Commission. The State Water-Supply Commission, after further investigation, still adheres to the plan of a reservoir on the Pompton River, one of the chief tributaries of the Passaic, to be formed by a dam at Mountain View.

The flood damages in the Passaic valley in 1903, a "careful estimate shows," were about $7,000,000. The commission believes that flood control here is only second to "water storage for potable purposes," and that both objects could be attained by the Mountain View reservoir.

After dwelling in general terms on the need of storage of potable water in the Passaic valley the commission becomes more specific, as follows:

To appreciate the gravity of the situation, the effect of this drought on one of New Jersey's largest supplies affords some interesting figures. The city of Newark, with its five large storage reservoirs, was undoubtedly as well if not better prepared for this emergency than any eastern city and yet up to the first of December it had drawn 4,100 million gallons from its reserve supply and out of the 9,770 million gallons representing a normal stage of the reservoirs there remained a supply sufficient for only six months more of drought.

A Water Rights Tangle.

That there are other than physical problems involved in looking after the water supply interests of New Jersey appears from this statement by the commission:

While never failing to appreciate the importance of the establishment of a large reservoir in the Passaic basin, and confidently believing it will be an accom-

*Certain phases of this matter were discussed editorially in our issue of last week, Dec. 31, 1908, p. 749.

plished fact in the not distant future, the commissioners have not been unmindful of the many problems which must first be solved before the work can be consummated. The true nature of the rights of the State in these waters for potable purposes, especially those of the Passaic, as against those who are now diverting the same, must be finally and authoritatively ascertained and the full extent and scope of the powers of the commission must be determined in the same way before any definite steps are taken to acquire reservoir sites. Until then, the work of the commission must be largely confined to further investigation and a study of the problems involved and the methods of their solution, a continuation of the measurement of stream flows and a discharge of the other duties imposed upon them by the act creating the commission. A definite financial plan whereby to meet the cost of construction and operation must of necessity wait until the determination of these rights and the ascertainment of the powers of the commission.

The controverted questions relating to water rights in the Passaic River center around the East Jersey Water Co. and numerous allied companies which supply water to a large portion of northwestern New Jersey and virtually lay claim to all the available potable water in that stream. To secure legal light on the subject the commission appealed to the Attorney-General of New Jersey. By way of explanation it said:

> The New Jersey General Securities Co. seems to be the holding company for the East Jersey Water Company's varied interests and it is understood to be the disbursing company for the several interests so allied. The East Jersey Water Co. seems to have as allied or subsidiary corporations, the Acquackanonk Water Co., supplying water to the city of Passaic and parts of Acquackanonk Township, including Clifton; the Little Falls Water Co., supplying water to the township of Little Falls; the Passaic Water Co., supplying water to the city of Paterson and borough of Prospect Park; the Montclair Water Co., supplying water to the town of Montclair, by distribution at retail, to Bloomfield by sale to the town by the million gallons, to Glen Ridge by sale to the Orange Water Co. by the million gallons, to West Orange by sale to the West Orange Water Co. by the million gallons, and to the Essex County public buildings in Verona township by sale by the million gallons. The above are all considered in the reports filed with the State Water Supply Commission under date of January, 1906, as diverting water individually from the Passaic River at Little Falls, and in addition to the above the East Jersey Water Company itself reports as diverting water from the Passaic River at Little Falls for Bayonne, Harrison, East Newark, Kearney, Nutley and Little Falls.

The water for these various municipalities is drawn from the Passaic River at Little Falls, N. J., at which point is located the mechanical filtration plant of the East Jersey Water Co., well-known to many of our readers.

In view of legal decisions cited in the report of the New Jersey Potable Water Commission for 1906 the present commission thinks it

> questionable whether the East Jersey Water Co., per se, has a legal right *to divert* water from the Passaic River, at least as against the State. It probably has a right to divert as against riparian owners, at least the riparian owners where any water power has been developed.

It appears that the company has maintained that in taking water from the Passaic at Little Falls it is merely acting as a contractor, but while this might or not be true as regards some of the communities supplied through subsidiary companies apparently some of the other places are supplied direct.

On Jan. 1, 1908, the East Jersey Water Co. first received certain properties from the Montclair Water Co., then transferred to the Passaic Water Co. a "⅜ part of water rights, rights of way, easements and tracts of land which embrace the pumping station and filter plant," and also transferred a ⅛ part to the Montclair Water Co. and 2/8 to the Acquackanonk Water Co.

No wonder, we may observe in view of the foregoing and only partial statement of these complications, the State Water-Supply Commission seeks legal advice as to how it shall proceed in collecting rentals for water diverted from the Passaic River. The perplexity is made greater by the fact that the law under which the commission is working states "that no payments shall be required until such *legal* [italics ours] diversion shall exceed" 100 gals. per capita supplied. The commission advises the Attorney-General that it

> is at a loss to know whether the diversion now taking place at Little Falls is a legal diversion, and whether if it is not a legal diversion, a charge can be made; and whether in the event of its not being a legal diversion, what proceedings, if any, should be instituted to restrain such diversion; and whether inaction on the part of the commission can be construed as an acquiescence in the illegal diversion of water.
>
> The commission also desires to know what, if any, procedure should be taken in view of section 2 of said Chap. 252, P. L. 1907, in the light of the recent transfers by the East Jersey Water Company to the several corporations above recited since Sec. 2 provides:
>
> No municipal corporation, corporation or person engaged in supplying or proposing to supply the inhabitants of any municipal corporation with water shall have power to condemn lands or water for any new or additional water supply, or to divert water from such new or additional source, until such municipal corporation or person has first submitted descriptions thereof, which may be accompanied by maps and plans, to said commission and until said commission shall have approved the same.

Recapitulating the above it would seem that if the East Jersey Water Company did not have a legal right to divert the waters of the Passaic River, the said company is now trying to vest a part of any vested rights it might have acquired in the Passaic, Acquackanonk and Montclair Water companies and that if said company did have a legal right to divert water from the Passaic River at Little Falls then it would not have a right to acquire any new or additional water supplies by this method without the consent of the State Water-Supply Commission.

The Attorney-General, in reply to this appeal, merely advised the commission to treat the East Jersey Water Co. like any other company and see what would happen—with the expectancy that this would bring the whole matter into the courts, which alone can give a conclusive answer to the points at issue.

Form of Permits Granted by the Commission.

As illustrations of the permits for taking water granted by the commission the following authorizations granted to a municipality and to a company, respectively, are given, with the omission of some of most formal portions:

> And the commission having at such public hearing heard all who presented themselves and desired to be heard, and having considered the matters and things set forth in the petition and the statements and representations made at such hearing, they do hereby decide that the plans so proposed by such borough [Mendham] are justified by public necessity or reasonable anticipated use, that they will not interfere unduly with the opportunity of other municipalities to obtain a water supply by taking of waters necessary for their use, and that the reduction of the dry season flow of any stream will not be caused in an amount likely to produce unsanitary conditions or otherwise unduly injure public or private interests.
>
> And they do further hereby approve of the application of said borough of Mendham for such new supply as is mentioned in its petition and shown on the map accompanying and filed with the same, upon condition that said borough shall complete the works mentioned in its petition within three years from the date hereof.
>
> * * * *
>
> (1) Such approval [application of Buckhorn Springs Water Co., of Belvidere] is granted subject to such annual charge by the State as now or may be hereafter authorized by law, for a period of 30 years with the right of renewal at the expiration thereof for 20 additional years.
>
> (2) Upon condition that at the end of the first 30 years of this grant or any time thereafter, upon one year's notice in writing served upon said company by the town of Belvidere, the said town may purchase the property and works of the company at a price to be mutually agreed upon without payment for diversion rights as against the State. If said town of Belvidere should purchase the property and works of said company during the first 30 years of this grant, the diversion rights hereby allowed to the company as against the State shall be limited to 30 from the date of this grant.
>
> In case such price cannot be so agreed upon then the same shall be decided by arbitrators, one to be chosen by the company, one by the municipality and the other by the two thus chosen.
>
> In case they cannot decide upon a third arbitrator, the same may be named by a Justice of the Supreme Court of this State upon application therefor by either party.
>
> (3) Upon condition that the said company shall complete the works mentioned in its application within two years from the date hereof and this grant shall not become operative until said company shall have filed with this commission its assent in writing to an agreement to accept the terms and conditions in this grant imposed.
>
> (4) Nothing in this grant shall be so construed as vesting any water rights in the town of Belvidere for a longer period than 50 years from the date of this grant without further permission of the State.

Compensation for Excess Water Diverted.

Under the law creating the commission municipalities or companies using surface water in excess of 100 gals. per capita per day (State Census of 1905 to govern) must pay the state for such excess at a rate to be fixed by the commission, but not to be less than $1 nor more than $10 per 1,000,000 gals. The rate has not yet been fixed in all cases, owing to the controverted points already mentioned, and the report does not state what rates have been established in other cases. The largest excess consumption reported makes a total for the year of 313 million gallons. The total excess for the state, if the table included in the report is complete, is not far from 500 million gallons, which would give a revenue for the year varying from $500 to $5,000, according to the rate charged. The commission expresses the opinion that in the future the revenue due from this will be considerable in amount.

In conclusion, it may be noted that the commission has established 16 gaging stations and provided for daily readings at the same, to determine "flows of the principal rivers of the state, particularly those being used for water supply purposes."

Mr. Morris R. Sherrerd, M. Am. Soc. C. E., of Newark, N. J., is consulting engineer, and Mr. Charles H. Folwell, of Mount Holly, N. J., is secretary to the commission, the offices of which are in the State House at Trenton.

Cast Steel Frames of the Arch-Bar Type for Car Trucks.

The diamond or arch-bar type of frame for freight car trucks is used to a much greater extent than any other type, but in the ordinary built-up frame the large number of parts results in considerable work and expense for maintenance and repairs. This is specially true of the bolts and nuts. The use of cast-steel truck frames made in one piece has been increasing during the past few years, but most of these require bolts for the journal-boxes or other attachments. A cast-steel frame which is now in somewhat extensive use embodies the advantages of the arch-bar type and also the important feature that the entire frame is complete in one piece and requires not a single bolt or rivet either in itself or for attaching other parts. The casting comprises the arch bars, columns, spring seat and even the journal boxes. The castings are of basic open-hearth steel having a high elastic limit. In case of derailment the frames may be bent but are not likely to break, and in most cases they may be straightened and returned to service.

A decidedly novel feature in the design is the casting of the journal-boxes as integral parts of the frame, instead of making these as separate parts to be attached by bolts, etc. The boxes can be made of any standard design, and

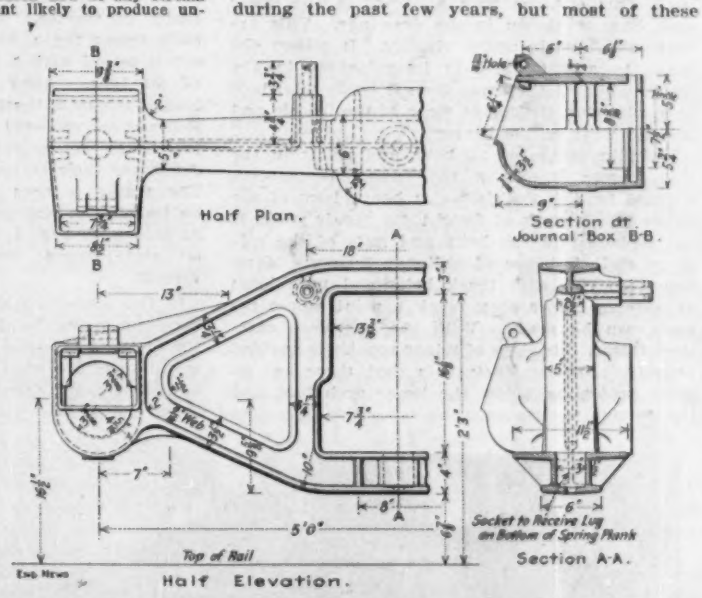

FIG. 1. CAST STEEL ARCH-BAR FRAME FOR CAR TRUCKS, WITH THE JOURNAL BOXES CAST AS PART OF THE FRAME.
(The Bettendorf Axle Co., Davenport, Iowa, Makers.)

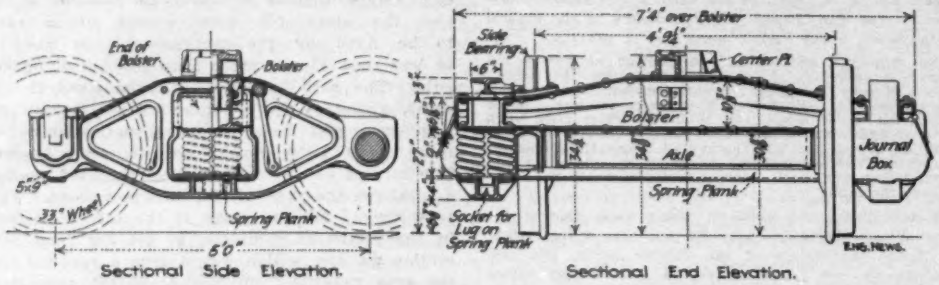

FIG. 2. CAR TRUCK FOR 80,000-LB. FREIGHT CAR, WITH CAST-STEEL ARCH-BAR FRAMES.

the makers guarantee to replace an entire frame if the boxes should fail either in normal service or in derailment. It is stated that in most cases where the boxes are damaged in a wreck or derailment they can be straightened in the railway shops. A lug on the bottom of the box provides for jacking when the truck is under a car. The truck must be dismantled when it is necessary to replace a pair of wheels, but it is stated that the dismantling of this truck takes less time than the removal of the journal-boxes from an ordinary truck frame having bolts, especially as the bolts are in many cases either rusted or bent.

A drawing of one of these frames is shown in Fig. 1, and a truck with frames of this kind for 80-ton cars is shown in Fig. 2. The bolster opening is of the shape used for a rigid bolster. For trucks with Barber roller-bearing bolsters and swing-motion bolsters, the column guides are vertical instead of offset. The spring plank is an inverted steel channel, and serves as a connection between the two side frames. In each end of its web is a circular lug formed by punching. This engages with a socket in the lower arch bar, as shown in the drawings. This arrangement avoids undue rigidity. It allows the truck to adjust itself to irregularities in the track, while at the same time it tends to reduce to a minimum the flange wear of the wheels and the end wear on the brasses.

The elimination of all bolts and rivets in the side frames is one of the important features claimed for this design, as a heavy item of the minor repair work at freight car repair yards is the replacing of the bolts and nuts of the columns and oil boxes of ordinary frames. Many cars also run with truck bolts and nuts loose or missing before they reach a point where repairs can be made. With the one-piece cast-steel frame, this class of minor repairs is avoided entirely. Another feature is that there are no parts projecting below the lower arch bar, and the minimum clearance between this bar and the rail is 4 ins. In addition to the simplicity, there is a saving in weight of about 1,000 lbs. per car, as compared with trucks having the ordinary built-up arch-bar frames.

Each frame is tested and squared in a hydraulic press of 975 tons capacity at the maker's shops. The first operation is the straightening of the spring seat and Fig. 3 shows a frame in the press with the dies bearing down upon this seat. After the spring seat is straightened, the frame is suspended on the seat ready to receive false or dummy journals which are slipped into the journal-boxes. A load is then applied equal to the capacity of the car with which the frame is to be used, and is therefore four times the load which the frame will carry in service. Thus each frame for a 40-ton car is tested with a load of 40 tons. After the load is released, the false journals are removed and the boxes are gaged to determine their accuracy. The frame is then laid on its side in the press, as shown in Fig. 4, and is straightened transversely.

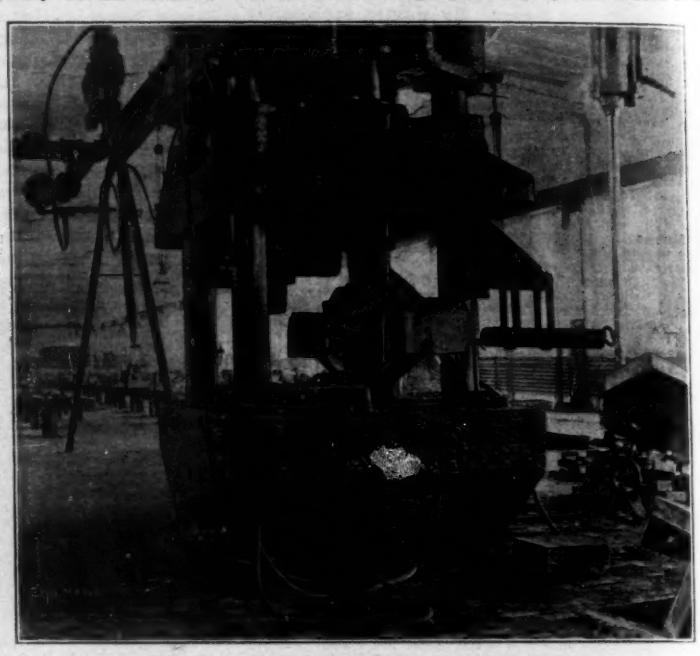

FIG. 3. TESTING CAST-STEEL TRUCK FRAME.

In the inspecting and finishing department an inspector gages the straightness of the frame and the distance between journal-box centers. Pneumatic tools are used to chip the column guides and dust-guard openings to proper gage, and to dress the journal-box openings so as to give a good fit for the cover. After this the frames are painted.

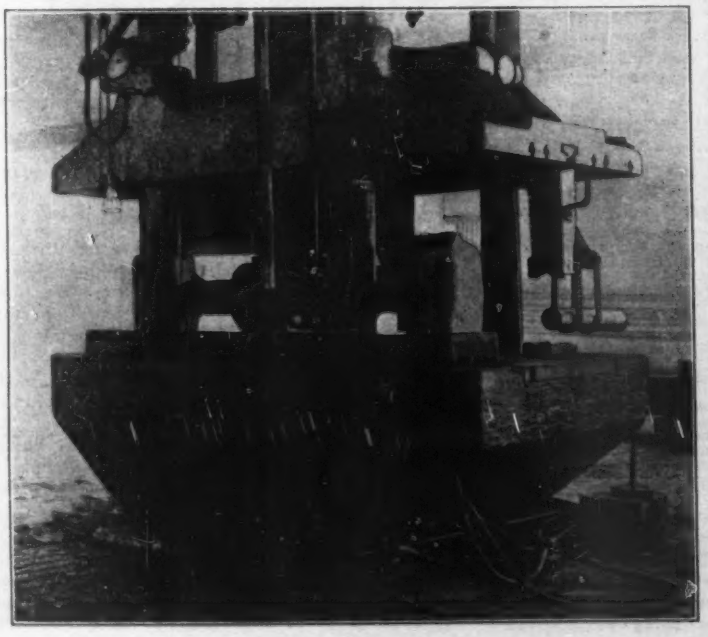

FIG. 4. STRAIGHTENING CAST-STEEL TRUCK FRAME.

The work of assembling a truck with these frames is greatly simplified owing to the small number of parts. The assembling is done on a track blocked a few inches above the floor, and the parts are handled by a 1,000-lb. hoist. A pair of axles with wheels mounted is run upon this track and one side frame is set in position. Its wedges and brasses are then fitted in the boxes. The truck bolster is next placed, and then the second side frame. The bolster is raised against the upper arch-bar to allow the spring plank and springs to be put in place, and the attachment of the brakebeams and brake rigging completes the work. The assembling of the truck requires only about eight minutes, and it takes about nine minutes to dismantle a truck under a car.

These cast steel arch-bar frames are manufactured by the Bettendorf Axle Co., of Davenport, Ia. They are in use for freight cars and tenders on a number of railways.

THE RAILWAYS OF CAPE COLONY, South Africa, had a length of 3,264 miles at the end of 1907 (with 3,385 miles of track), as compared with 3,197 miles at the end of 1906. The additions included 9 miles acquired from a municipality, 33 miles of new line of 3½ ft. gage (the standard gage of South Africa), and 21 miles of new line of 2-ft. gage. In addition, there are 393 miles of side track. The maintenance expenses have been very low for some years, but the report intimates that the limit has been reached. Broken rails and broken splice bars are becoming more numerous, and the track needs strengthening. Some new bridges were built and others were strengthened. The tie plantations have been extended, and planting has been continued. The remaining old iron ties are being replaced rapidly with wooden ties.

No new locomotives have been ordered since 1903, except three engines of three distinct types. The passenger locomotive equipment is said to be below the requirements. An experimental three-cylinder compound shows a saving of 15 to 20% in fuel consumption as compared with simple engines hauling the same load, and using a poor mixture of coal. Additional car repairs will be necessary in the future, and many of the freight car trucks are a source of extra expense through having been built too light in order to meet a demand for a reduction in the proportion of dead load to live load in the freight cars. The equipment, 654 locomotives (16 of 2-ft. gage), 4 motor cars, 987 cars in passenger service (42 of 2-ft. gage), 10,306 cars in freight service (172 of 2-ft. gage), 37 traveling cranes and 40 wrecking cars.

The results of operation have been unsatisfactory, the traffic and revenues continuing to decrease, in spite of rate reductions and other means taken to encourage traffic and reduce expenses. The annual report of the general manager recommends reductions in train service, an increase in freight rates on certain commodities now carried at a very low rate, and a reduction in passes and special rates. In certain districts ox-wagon competition is serious; this is especially the case when the road transportation is in the hands of natives, whose wants are few and who can therefore make extremely low rates. The expenditures were reduced 5.7%, but the decrease in total earnings was 6.87%, following a decrease of 8.03% in 1906. The passenger earnings decreased 9.58%. The train mileage aggregated 8,347,000, a reduction of 9.35% over the previous year. The total earnings for 1907 were $17,348,525; the expenditures were $12,963,170, of which $2,047,625 were for maintenance-of-way and structures, and $275,525 for new works and betterments.

The railways are owned and operated by the colonial government. The particulars given above are from the annual report for the year 1907. Mr. T. S. McEwen is General Manager; Mr. G. C. S. Clark, Chief Traffic Manager; Mr. H. Beatty, Chief Locomotive Superintendent, and Mr. Allan Grant Dalton, Engineer-in-Chief.

ENGINEERING NEWS

A Journal of Civil, Mechanical, Mining and Electrical Engineering

Published every Thursday by

THE ENGINEERING NEWS PUBLISHING CO.

220 BROADWAY, NEW YORK

BRANCH OFFICES

CHICAGO: 1636 Monadnock Block
WASHINGTON, D. C.: Home Life Building
ATLANTA: Candler Building
RUDOLPH MOSSE, BERLIN AND HAMBURG, GERMANY
Z. P. MARUYA & CO., Ltd., TOKYO, JAPAN

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Entered at the New York Post-Office as Second-Class Matter.

From an editorial in "Harper's Weekly" for Dec. 26. [Edited by Geo. Harvey. Published by Harper & Bros., a corporation. W. M. Laffan, President of the New York "Sun," is a member of the Board of Directors.]

Evidences multiply daily that the most serious problem confronting the new administration is that involved in the construction of the Panama Canal. The original estimate of $145,000,000 faded into insignificance long ago. Lindon W. Bates, an engineer of the first rank, now puts it at $550,000,000, with careful reservation to the effect that probably a much larger sum will be required.

The chief point of contention relates to the foundations of the great Gatun dam. This structure will be more than a mile long and required to hold a body of water eighty feet deep and covering several square miles of basin. The pressure on some portions will be 14,000 pounds or more to the square foot. The French engineer, Bunau-Varilla, has maintained consistently from the beginning that no dam could be built upon a foundation of blue clay that would withstand this tremendous weight. Professor Burr, of Columbia University, and Mr. Bates, both eminent men, confirm this judgment.

The official report, however, pronounces "the material encountered of such character as to be amply strong for supporting the proposed structure." The statement is sufficiently explicit, but does not sound convincing or like the utterance of a mind fully convinced itself. Surely the condition is, as we have said, at least disquieting.

But what is to be done when doctors disagree? Mr. Taft announces that he is going down to look things over. Why wouldn't it be a good idea, in fact, for Mr. Taft to get somebody to go along who knows and is known to know his business? Some months ago we ventured the assertion that the man best equipped to build the canal, if he would undertake the job, was Edward H. Harriman. The suggestion was offered with no expectation of its being acted upon, owing to certain personal differences which need not now be recalled. But we renew it now in all seriousness.

"The really vital question," declares the Herald, "is whether it would not be better to drop the canal now and forever."

We cannot believe that the situation is as serious as that; but it is serious, very serious, not only to the country, but to President Roosevelt, whose monument the great waterway, if successfully completed, will be, and to President Taft, who must bear the responsibility for what is done from this time forward.

It is too much to expect that Mr. Harriman could be induced to build the canal, but he could hardly refuse, if asked, to make a thorough inspection, and submit a report that would be accepted as authoritative, at any rate.

From a speech by Francis J. Heney, Prosecutor of the San Francisco graft cases, delivered before the City Club of Philadelphia, Jan. 2.

"San Francisco is no worse and no better than the average American city. The causes of corruption are the same in all cities. In San Francisco we found two elements at work. Coming from one source was the Public Service Corporation and from another were the saloons and dives, while behind our backs these forces joined hands.

"In this unholy alliance the boss was the connecting link, but he was simply the agent of the real boss—the big business man who wanted to exploit the Public Service Corporation. The political boss was really the small duck in the pond. Behind him was the Public Service Corporation and the Southern Pacific Railroad.

"According to my deduction, the head of the legal department of the Southern Pacific Railroad, W. F. Herrin, was the boss behind the apparent boss; but I am convinced that Herrin was, after all, the tool of the actual boss—Harriman.

"We must reason from cause to effect. The corruption of the city life in San Francisco was not found in the deals made by Reuf, but was due to the fact that Harriman wanted to use certain men. Our real boss sits in New York City and reaches across the country in working out his schemes.

"They say when these things are discussed that they must employ such means. They argue from the same premises that Jimmy Logue did when he planned to rob a bank—that he was in need of the money. The Public Service Corporation and the railroad wanted something for which they were not willing to pay the public, which owned the franchises they wanted to get under their control. It was easier to purchase the political boss and the councilmen, so the respectable business man sends his agent into the public market to get the goods."

There was a time when "Harper's Weekly," with Geo. William Curtis in the editorial chair and Nast with his cartoons fearlessly attacking corruption in high places, ranked as one of the great moral forces of the nation. How has the mighty fallen! The financial failure of the Harper publishing house and the assumption of control by representatives of large financial interests are matters of recent history, as are also its attacks upon the Administration.

We have thought it worth while to reprint the above editorial (condensed from a much longer one) as it sheds some further light on the sources from which have arisen the recent stories of trouble with the Panama Canal work. As Mr. John F. Stevens remarked in his letter published in our last issue, the sudden outburst of attacks on the canal enterprise is very suggestive. It looks very much as if an organized systematic attempt were being made to deceive the American public regarding the canal work, and what shall we say of the journals and the editors that engage in such deception?

Fortunately, there is not the smallest reason to believe that such a conspiracy can be successful. Wall Street financiers, accustomed to fool some of the people all of the time, may be foolish enough to propose turning over the Panama Canal enterprise to the tender mercies of the Southern Pacific Ry.; but Wall Street had better inquire how the idea takes in California!

Mr. Harvey sagely remarks that "it is too much to expect that Mr. Harriman could be induced to build the canal," and there is not the slightest reason to doubt Mr. Harvey's statement on this point.

The earthquake which has devastated the southern end of the Italian peninsula and the adjacent shore of Sicily seems certain to rank as the greatest calamity of history in the number of lives blotted out. The news dispatches thus far have related to those aspects of the disaster that appeal to the popular mind and there has been very little definite and reliable statement as to the scientific and technical aspects of the earth shock.

So far as present reports may be trusted, however, it would appear that the violence of the earth shock was confined to a comparatively small area. Messina appears to have suffered more severely than any city on the mainland opposite; but the winter resort of Taormina, some 30 miles away, is said to be comparatively little injured. The fact that railway trains were run to carry survivors from stricken Messina to Catania on the east shore and Palermo on the north, would indicate likewise that the distortion of the earth's surface cannot have extended far from Messina else it would have been impossible to have put the railway into condition for service in any brief time.

Latest reports indicate, too, that the enormous destruction of life was chiefly due to the earthquake and that the tidal wave and the fires contributed comparatively little to the fatalities. It seems probable that the explanation of the enormous loss of life is to be found in the density of population in the stricken district and the prevalent type of building construction rather than in the actual violence of the earth shock, even though this was undoubtedly one of the most severe that has occurred in Europe since the dawn of history.

In these lands of southern Europe from which the forests available for building purposes were long since swept away, the universal material of building construction is stone or brick, with roofs of tile. The mortar used is doubtless of ordinary lime, or at best of pozzolana. That buildings of such materials are certain to go to pieces under an earth shock of any severity is well known; and their unfortunate occupants are almost as certain to be caught and crushed like rats in a trap.

The people of Japan, where earthquakes are both frequent and severe, learned long ago that to withstand earth shocks the lightest material was the best. Had Messina been built up of bamboo frame structures with partitions of matting, like a Japanese city, it is likely that most of its people would have escaped uninjured, save those near the water front where the tidal wave spent its force. Of course the Japanese type of construction will only suffice in a climate where severe cold never comes; but southern Italy and Sicily fortunately possess such a climate, and its people, like all Europeans, are accustomed to life with little or no artificial heating of dwellings. It should be possible to rebuild the ruined cities, therefore, in a manner that will remove a considerable part of the danger from earth vibrations.

In the railway world it is very common to hear of high officials who have risen from the ranks, but so much publicity has not always been given to the fact that there has been a lower limit at which the "ranks" stopped, and that below that limit there were a very considerable number of men who, except under extraordinary circumstances, never could rise above a minor position. In this latter class were the track laborers who, with diligent application and long service, might become track foremen, but could never by any possibility be promoted to any higher position in the Pennsylvania service, no matter how faithful their work or how manifest their ability to carry larger responsibilities.

This policy recently has been changed by the Pennsylvania R. R. This road announces that in future the position of Supervisor may be filled from the list of track foremen instead of exclusively through the engineer corps, as heretofore practiced. In token of this new order, a competent track man, who started in as an ordinary laborer at fifteen years of age and had become a track foreman and then a General Foreman of Track Laying, an office created for him especially, has just been appointed an Assistant Supervisor, from which position he is considered in direct line of promotion to Super-

visor, Assistant Engineer, Superintendent or higher.

While it is quite probable that natural deficiencies and lack of opportunity for wide study will prevent most of the 1,500 track-foremen on the Pennsylvania from profiting by this new order, it still has the great advantage of offering some incentive to good work and study among the more progressive and ambitious of these privates in the great railway army.

We trust that San Francisco's project for a municipally-owned water supply will not become befogged by any unwarranted claims that the proposed reservoir and accessory rights of land and water control would ruin a large part of the Yosemite Park. Far be it from us to urge anything that would injure that or any other of our government reservations, but on the face of it there appears to be no reason why a storage reservoir in any one of the great national parks might not add to rather than take from both their attractiveness and utility. The names of that veteran explorer and wild-nature lover, Mr. John Muir, and of Robert U. Johnson, Associate Editor of the Century Magazine, who, with Mr. Muir, did valiant work to secure the creation of the Yosemite National Park, are both mentioned in opposition to the San Francisco scheme. These and other names vouch for the genuineness and earnestness of the opposition, but do not prove that broad grounds of public policy will not warrant Congress in authorizing the land transfers to San Francisco, which, we understand, have already been approved by Secretary of the Interior Garfield.

No one will question that Mr. Muir and Mr. Johnson speak with much knowledge when they oppose the grant on grounds of preserving natural scenery, although press reports state that Mr. Johnson admitted at a Congressional hearing that he had never been in Yosemite Park. But when Mr. Johnson ventured outside his familiar though untrodden fields and attempted to show that San Francisco had no need of the proposed new water supply in order to defend itself against private water monopolies, it appears to us that he is on far less certain grounds. Moreover, Mr. Johnson appears to have gone further and made himself, presumably without intention, the champion of the water monopolists. That is, if the following newspaper account of his remarks on the subject are correct:

> The water franchises of the city of San Francisco, said Mr. Johnson, are now divided between the Bay City Water Co. and the Spring Valley Water Co., the latter concern owning practically all the city's water mains. But the city's argument, said Mr. Johnson, that they need the new water grants in order to enable them to resist a monopoly is unfounded, because the water company does not fix rates, but the water is sold to the city and the populace at a rate fixed by the courts.
>
> As it is, he said, the Secretary of the Interior's action has gone so far that the city is using its prospective grant in the National Park as a club wherewith to beat the Spring Valley Water Co. into submission, with the ultimate idea of buying out the concern and running its own water supply.

Leaving out of account Mr. Johnson's evident confusion as to the physical status of the present water supply of San Francisco, it may be noted that to all intents and purposes the Spring Valley Water Co. does not fix its own water rates. The constitutional provision that county supervisors (not the courts, as Mr. Johnson says is the case for San Francisco) shall fix water rates throughout California has been made virtually of no effect in San Francisco for years past because the water company has kept in the courts the rates ostensibly fixed by the supervisors. Moreover, attempts at rate-fixing have been largely farcical, anyway, owing to a variety of conditions which cannot be set forth here.

As to Mr. Johnson's assertion that San Francisco is using the proposed new supply as a club over the Spring Valley Water Co. to bring it to terms, why shouldn't it do so, and why should Mr. Johnson and numerous other gentlemen take up the cudgels in behalf of a company which has shown itself amply able to protect its own interests?

If Mr. Johnson and his other Atlantic seaboard friends (curiously enough these opponents of the scheme in question are all far-easterners, save Mr. Muir) lived in San Francisco, perhaps they would feel that municipal ownership of waterworks was of a hundred times more vital importance to them than all the beauties of the Yosemite Park. For thirty years or more the people of San Francisco have been trying to free themselves from one of the most complete and burdensome water monopolies that has ever existed on this continent. One by one they have seen practically every large city in the country change from private to public ownership of water-works, unless public ownership already prevailed. In some states the change has extended to the smaller cities and towns. In Massachusetts to-day, each and all of the 33 cities and every town above 8,000 population, save two or three, own their water-works.

While such facts do not justify the destruction of natural scenery in the Yosemite Park, they do suggest that those whose chief concern is the park should either confine themselves to that subject or else thoroughly post themselves as regards the reasons why San Francisco wants to own and control its water-works.

How much longer will the taxpayers of New York City continue to pay one to five dollars of expense charges for every dollar of property value in land condemnation cases? The question is of more than economic interest to our readers because many of these enormous and unwarranted expenditures finally go to swell the apparent cost of engineering works, and the blame for the excessive cost is laid on the engineers!

The bars have just been let down into one of the most fruitful fields ever opened to condemnation commissioners and a numerous flock of these gentlemen and their hosts of followers have begun to fatten on the rich feed thus offered. We refer to the land takings for the large reservoir sites and the hundred miles of aqueduct right-of-way for the Catskill water supply for New York City. It is reported that 24 commissioners are already at work in this field and that the number will soon be doubled. It is also said that thus far a total of $675,457 of awards for land have been made, with expense bills for $859,074 in addition. This seems modest compared with many previous condemnation proceedings in New York, but the showing may be far different before the proceedings close, for it is said that no final report has yet been filed.

Appointments to these commissionerships are made by Judges of the State Supreme Court, but that does not seem to be any protection to the city. In fact, it is alleged that at least one tried-and-true politician or political hanger on gets on each commission. Rarely, so far as we know, are commissioners chosen because of their experience and judgment in appraising land to be taken for public purposes. Once appointed, the chief object of the commissioners seems to be to hold as many sittings and to make each one as short as possible, compensation being on the per diem basis.

Fortunately, the Comptroller of the City of New York and various civic organizations and public-spirited citizens have taken up cudgels against this time-honored abuse, so there is some hope of reform. Perhaps the present commission on revising the charter of New York will submit a proper substitute for the present system, so far as takings outside the Catskill water supply scheme are concerned.

Just what system of condemnation proceedings would be the best substitute for the one now in vogue we cannot say. The main considerations are: (1) Appraisals fair in price to all concerned; (2) expedition instead of almost endless delays in the proceedings; (3) keeping the collateral expenses down to reasonable figures, which is largely dependent on (?) or the expedition of the commissions. Some basis of compensation other than by the day seems to be an essential of reform. It would hardly do, however, to make the compensation a percentage of the awards, for obvious reasons.

Perhaps some of our readers can report satisfactory condemnation practices in use elsewhere.

How May the First Steps in Conservation be Taken?

Of the many forward movements for the public welfare which have been originated by President Roosevelt, it is probable that none has awakened more universal approbation and received less criticism than the movement for the conservation of natural resources. Our readers are familiar already with the epoch-making character of the conference held at the White House last May, attended by the governors of the states and the heads of the executive, legislative and judicial departments at Washington. It is well known, too, that as an outcome of that notable meeting, commissions to study and report upon the conservation of resources were appointed by the President and by the governors of many of the states.

A great work has been done unquestionably in bringing this most important subject to public attention, and in a most effective way. And yet, evidences multiply that only a beginning has been made, and that when it is actually attempted to compel the preservation for posterity of some part of what we are now recklessly wasting, the task will be found full of difficulties.

It is in some respects unfortunate that the conservation movement in the public mind has been chiefly identified with forest preservation and restoration. Important as this is, it is almost certainly of far greater importance to take measures for preventing waste of our mineral wealth. Forests can be restored. The lessons of the coming timber famine are certain to sink deep into the popular mind, and radical action for reforestation can be brought about probably with no very serious difficulty. But the minerals beneath the surface of the ground are an accumulation made by nature which can never be replenished by any artifice of man. Once used up, the race must get along without them as best it may.

It may be argued that as respects some of these mineral deposits the race may utilize substitutes as one becomes exhausted. Natural gas, for example, valuable as it is, can be replaced by oil and artificial gas in almost every instance; and petroleum can to some extent be replaced by the distillation of bituminous shales. But the point to be emphasized and made clear to the public is that every such substitution means a certain loss, a certain increase in cost, and this translated means that certain individuals, towns or even states, will lose some of the wealth and prosperity that they formerly enjoyed.

We pride ourselves on the wealth of the United States, the high wages and the opportunities offered for the industrious and competent man in almost any occupation to acquire comfort and a competence. We have thoughtlessly ascribed these conditions to our free and stable government or to superiority of race. But more thorough studies would almost certainly show us that the underlying reason for the abounding prosperity of the United States is its wealth of natural resources; its fertile soil; rich mineral deposits, and extensive forests. If one has any doubt as to this, he needs only to compare certain sections of the country, where the soil is sterile, yielding small returns to the farmer and where mineral deposits are lacking, to see how closely the prosperity of any section is related to its natural resources.

It is, of course, true that by the aid of modern transportation facilities, sections of little natural wealth have been enabled to build up manufacturing industries; but these sections are then dependent upon the natural resources of other sections for their prosperity.

We can go even farther than this: Our own country, new as it is, is already dotted thickly with object lessons of the poverty that inevitably follows the exhaustion of natural resources. The abandoned farms of New England tell of soil robbed of its virgin fertility. The ruins of saw mills and tanneries are to be found wherever forests have been swept away, and with these industries have gone the popu-

lation they once supported. In the mining regions and the oil and gas regions of the country likewise, one continually finds deserted homes, villages and even cities falling into decay, and the pitiful relics of mills and machinery which became useless when the stores beneath the earth's surfaces were all gone.

Admittedly a part of this exhaustion of nature's stores was inevitable, but another part, and probably the larger part, was due to the reckless and wasteful manner in which these stores were exploited. It is waste and wasteful use rather than necessary use that has already destroyed in many sections the foundations of prosperity.

It ought to be clear, therefore, that the very first step in the conservation of our resources must be the prevention of waste. In order to give our readers a striking picture of the waste that is to-day going on in one great industry we have reprinted below two recent papers, one describing conditions in an oil field in southeastern Illinois, the other near Shreveport, La.

Each of these descriptions is a picture of ignorant and wanton waste continuing day after day, month after month, and year after year and on an appalling scale. The question arises whether the race is yet wise enough and advanced enough in the scale of civilization to put an end to such waste. Is the old savage instinct of neglect and improvidence still so strong within us that we shall turn a deaf ear to the warnings of those who perceive that we are literally burning up and destroying what could provide comfort and prosperity for many millions of people?

Suppose a traveler from another planet were to visit the earth and witness the rate at which its inhabitants are using up the elements by which their life is sustained and the waste that is going on. Suppose such a one were to visit such scenes as those in the oil fields of Louisiana and Illinois or the great oil geyser in Mexico described in our issue of Dec. 10. We can imagine a conversation between such a visitor and an intelligent American who should attempt to satisfy his queries about as follows:

Visitor.—You tell me that this oil and gas is a valuable fuel, why, then, is it allowed to go to waste in this way; are there inexhaustible stores of it to be found everywhere?

American.—No, the deposits of oil and gas occur in only a few localities and we have found by experience that the gas in any field when wells are driven is soon used up and the oil is also exhausted after a few years.

Visitor.—Why, then, is there such haste to exhaust these oil and gas fields? Would not they last much longer if fewer wells were driven and the oil and gas were taken to the surface only as fast as there was a market demand for them and storage facilities were provided?

American.—Undoubtedly, but those who drill the wells and the owners of the land likewise are intent upon present profit and have little thought or care for those who come after them. Besides, each man fears that if he does not sink wells and extract the oil from below his own land, his neighbor adjoining may sink wells and tap the reservoir.

Visitor.—Does a man who owns land on the surface own also the oil or gas beneath it?

American.—Yes, but the oil or gas in the porous rock beneath may flow to a well sunk on the neighbor's land; for this reason, everyone is in haste to draw out the oil lest another secure it first.

Visitor.—Then does not your system of private ownership of mineral deposits tend to discourage even temporary conservation or careful use of these stores?

American.—Undoubtedly, and this is particularly the case with oil or gas deposits in the porous rocks far beneath the surface. Unless the control of an entire deposit were in a single owner's hands, it were useless for any one man to refrain from driving wells on his property; his neighbors, who drove wells, would exhaust the reservoir beneath just the same.

Visitor.—Why do people who own the land surface own also the minerals lying beneath it? Are not these gifts of nature which should be equally shared by all men alike?

American.—Many of our own philosophers and statesmen have put forth such views; but until very recent times, ownership of property has been settled by might instead of right. Further, it has been found that land held in common ownership or under public control is not cared for as well or used as efficiently as land privately owned; and the same rule has been believed to be applicable to ownership of mineral deposits. Our laws, however, do recognize that public necessities are superior to private ownership and the state has always the power to take away the property of a private owner when the public needs require.

Visitor.—You could then under your system make laws to prevent waste of these natural resources by private owners, could you not?

American.—In theory, yes; and such laws have been strongly urged by some of our wisest public men. But the enactment of all such laws conflicts with the interests of those who are anxious only to get rich quickly by exploiting these oil and gas fields. These men therefore offer organized and active opposition to all such laws. As the public is for the most part wholly ignorant of this waste and of its terrible significance to the

The Development of an Oil Field and Its Lessons.*

The Illinois oil field lies in Crawford County in the neighborhood of Casey, Robinson and Oblong, and prior to the discovery of oil the land was used exclusively for agricultural purposes.

In the spring of 1903 someone, drilling either for an artesian well or gas, struck a fair flow of oil. No sooner had this discovery been made public than the farmers living near Casey were besieged by multitudes of alert oil operators who were able to lease the lands in most cases for a mere trifle. A great many farms were put under contract for 12½ cts. an acre, plus ⅛ of the oil marketed, as the owner's royalty. Even this small sum was a welcome gift to the thrifty farmers for they were faithfully promised that the oil operations would in no way interfere with the usual routine of farming. So it was that they fairly tumbled over one another in an effort to get some of the easily earned gold.

Derricks were hauled out and set up in a single night; drillers began with feverish haste to drive their long steel casings into the unresisting earth; and the oil commenced to flow. The first successes naturally served to heighten the excitement. Still more operators appeared, and in the face of brisk competition prices rapidly rose from 25 cts. to $1, $2, $3, $5 and even $10 an acre. Lessees were now glad to concede landowners 1-6 of the oil in order to gain control over more of the valuable farms. Hundreds of rigs were rushed to the scene—some by special trains—and the amount of drilling was trebled in a few weeks. Some occasional dry holes were struck. but, for the most part, oil sand was found in large quantities and the wells proved good.

By no means the last of the producer companies to realize the immense value of the Casey field was the Ohio Oil Co., an Illinois branch of the Standard. Prospecting toward all points of the compass from the central claims, its agents soon expanded the field in a southerly direction where they obtained large holdings in the vicinity of Oblong. Still better prices prevailed here, the land bringing $30 to $50 an acre with 1-6 of the oil additional. A well that will produce 10 barrels a day is considered by experts to be worth pumping. In this locality several of them were found to flow 1,000 barrels daily immediately after shooting, and to run for six months or more with only a slight falling off from this rate. Natural gas, nearly always the companion of oil, was so profuse that it took the place of all other fuels, and was used universally for lighting purposes. After dark the country was illuminated for miles around by great 10-ft. gas flames, issuing from standpipes, which burned throughout the day as well as the night. So strong was the flow of oil here that experienced drillers nearly always dug a pond around a well to catch the first rush. When the 80 odd quarts of nitroglycerine was exploded, the oil would come roaring up out of the casing in a mighty column 2 ft. thick where it left the ground. Shooting over the top of the derrick—sometimes to the height of a 12-story building—this stream of heavy black oil scattered over the ground for a hundred yards around, killing the crops and ruining the land.

But the farmer did not mind. His days of hard toil were over, at least temporarily, and he gloried in seeing this thick, ill-smelling fluid heap up its enormous volume against the makeshift dam at the low end of the oil-pond, finally to break through it and go thundering down the hillside to the creek bottom.

So rapid was the development work, that inside of a year the county was literally smeared with oil from one end to the other. Hundreds of thousands of barrels of it ran out of the wells before they could be capped; spread over the fields of swaying grain, laying them waste; polluted the rivers, killing the fish and sickening the cattle that drank from them; and converted the roads into terrible oil slews into which horses often sank up to their bellies.

But even this did not stop the constant drilling. The oil was there and so was the determination to pump it out. As soon as enough producing wells were brought in on a lease, the contractor erected a pumping station and tanks for temporary storage of the oil. The Ohio Company built a large pipe line from this field to its oil-farm near Casey, where it owns more than a hundred steel tanks of 35,000 barrels capacity each. On the McKnight farm, which is probably the most productive in Crawford County, there are three wells which, although two years old, still have sufficient force to flow oil a distance of a half a mile, uphill, and fill eight 1,600-bbl. tanks without any mechanical assistance. When these tanks become full, the "gager," who is a government employee, measures the amount of oil in them, leaves a statement with the superintendent, and turns their contents into the Ohio's pipe line. It is then pumped to the oil farm—a distance, in this case, of 30 miles.

As a result of spirited competition and the unusual number of good wells brought in, the value of leases continued to rise up to the moment when the last bit of ground was placed under contract. At this time a tract of about 50 acres brought $175 an acre and 1-6 oil, royalty. Many owners who fell victim to the first excitement and allowed their farms to go for a few dollars have been fighting in the courts ever since in an effort to break their leases that they may realize for themselves the enormous profits which are going daily into the pockets of the operators. But the law is just and refuses to strip the reward now from those who took all the chances of failure at the beginning.

So it is that conditions have so wonderfully changed in the oil district of Illinois. Five years ago the golden grain waved its glad message to the farmer's heart; today his ruined fields are dotted with tall, black derricks standing like grim sentinels over an army of oil-smeared tanks. While the oil runs the people will prosper; and experts have declared this Illinois field to be still in its infancy.

*Condensed from a paper by Richard E. Wiles in the "Yale Scientific Monthly" for December.

Waste in a Louisiana Oil Field.*

The Caddo oil field is about 25 miles northwest of Shreveport, La., in Caddo Parish. As at present outlined by preliminary well drilling the field is very narrow and is about 10 miles long in a northwest-southeast direction, but geologists of the Survey who have recently visited the field report that although its exact limits have not yet been determined it is probably of much greater extent than has been supposed.

This field has but lately come into prominence as a producer of petroleum, but it includes gas wells that have for several years given evidence of very great pressure. About four years ago one of the gas wells in this field began to leak badly around the casing, as a result of poor work in packing the well above the gas-bearing sand. This leakage rapidly increased and the well soon "blew out"—that is, the pressure of the gas blew the pipe out of the ground and tore away the surrounding earth, and the pipe, derrick, drilling apparatus, etc., all fell into the well and were submerged by water which blew out with the gas. Gas continued to blow out from this well for about four years. Around another well a crater about 300 ft. in diameter has been formed, which is usually half filled with water or thin mud containing some petroleum. In the middle of this the gas boils up, making a large mud volcano, and periodically the entire crater fills with oil and water and overflows into Caddo Lake.

Persons familiar with gas wells have estimated that 15,000,000 cu. ft. of gas is wasted from this well in 24 hours. A still greater waste is reported at a dry well about a mile due west of this one, where the gas is burning with a flame varying from 70 to 100 ft. in height.

No effort whatever is being made to control these wells. The oil men have a fanciful belief that after the gas has blown off the production of oil will be improved, but there is no justification for this belief, for the rapid escape of gas rather injures the oil chances of the field by permitting an influx of salt water as the gas pressure is removed.

The real reasons for this profligate waste, apparently, are the facts that there is no immediate use for the gas beyond that now supplied to Shreveport and Texarkana, and that the sensational spectacle of this burning gas at night will advertise the field to those passing through it on trains.

By the President's order the Secretary of the Interior has just withdrawn from entry all the public lands, embracing about 6,500 acres, in this oil field. This action is taken pending a careful geologic investigation by the United States Geological Survey with a view to preventing a waste of natural gas that has been estimated at 75,000,000 cu. ft. a day, or more than one-twentieth of the amount of this fuel usefully consumed in the entire United States.

*From a bulletin issued by the United States Geological Survey.

country at large and to the generations that are to come after, attempts at legislation to restrict waste have generally failed.

Visitor.—Could not the Government take possession of all such mineral deposits and exploit them in a scientific way for the general public benefit?

American.—Such nationalization of mineral deposits is being undertaken on a large scale by several foreign nations, but the majority of public opinion in the United States does not yet favor it. The principal argument against it is that Government administration is necessarily cumbrous and more or less inefficient and corrupt.

Visitor.—But is there no combination of public control with private operation that can be put into effect to stop this appalling waste?

American.—If such a combination could be devised and put into successful operation it would undoubtedly save many hundreds of millions of dollars of valuable natural resources from destruction. It has been proposed that the State or Federal Governments assume control of mineral deposits, regulate their working in such a manner as to keep down waste and assess a tax on the output, particularly of such minerals as are now being wastefully used. So long as any product of the earth or soil is produced at abnormally low cost, so long its waste and wasteful use is certain to continue.

Visitor.—But could such radical laws as these be enacted in the face of the opposition of private interests of which you have told me?

American.—Of course there would be strong opposition, but on the other hand there would be a stronger sentiment for such laws than could possibly be secured for any that merely attempted to restrict waste. The idea is gradually taking root in this country that every man is rightfully entitled to some share in the gifts of nature. Again, when everything concerning mineral deposits was a deep mystery, it was entirely natural that the discoverer of ore should be held to be its legal owner. But the discoverer is seldom the man who reaps the profit from an ore deposit and the public is looking askance now at the vast fortunes which have been made and wasted by some of the present-day mine owners and inquiring by what right they possess their great wealth.

Moreover there are already precedents for the laying of a special tax on mineral products. Canada, a few years ago, laid a special tax on all gold produced within its territory. The State of South Carolina formerly received a large part of its revenue from a tax on the phosphate rock mined within its territory. Other nations lay a tax on the export of those minerals whose production and use at home tends particularly to the benefit of industry. Hence, if it were deemed for the public benefit that a tax should be laid on products whose waste threatens to destroy the foundations of public prosperity, such a tax would almost certainly be approved by the courts and also by the final court of public opinion.

LETTERS TO THE EDITOR.

Questions Used in Examination for Junior Engineers, Technologic Branch, Geological Survey.

Sir: The enclosed examination paper may be of interest to some of your readers. It was given by the U. S. Civil Service Commission to secure eligibles from which to make certification to fill vacancies as they may occur in the position of junior engineer in the Technologic Branch of the Geological Survey, at salaries ranging from $840 to $1,200 per annum.

The questions are not given word for word, but are practically the same as the originals. The vacancies to be filled in the junior engineer grade are in three distinct lines of employment. The following set is such that an educational groundwork corresponding to the degree of B. S. in civil engineering should qualify the applicant. The weights of the various subjects and the time allowed is given below:

Elementary chemistry, physics and mathematics	10%—2½ hrs.
Essay of not less than 500 words on a civil engineering subject accompanied by drawings (both English composition and drawing will be rated on this subject)	20%—3½ hrs.
Mechanics and dynamics of engineering	10%—2½ hrs.
Testing of structural materials	25%—3½ hrs.
Training and experience (rated on application form)	35%—
Total	100%—12 hrs.

Yours very truly, "A Civil."

——— ———, Iowa, Dec. 4, 1908.

[The list of questions follows.—Ed.]

EXAMINATION FOR JUNIOR ENGINEERS, TECHNOLOGIC BRANCH, GEOLOGICAL SURVEY, DEC. 2 AND 3, 1908.

Elementary chemistry, physics and mathematics.

1. What are the products resulting from destructive distillation of coal?
2. What impurities in water causes scale in boilers? How may it be avoided?
3. How many pounds of air will it take to burn one pound of carbon to make carbon dioxide, CO_2? How many pounds of air will it take to burn one pound of hydrogen? The per cent. of oxygen in air is .238; of nitrogen .762. The atomic weight of oxygen is 16, carbon 12, hydrogen 1.
4. What is the relation between the pressure and the volume of a mass of gas?
5. Explain fully why water is not instantly converted into steam at the boiling point.
6. What is meant by the mechanical equivalent of heat? Give its value in English units.
7. Reduce 50° F. to Centigrade degrees.
8. Explain what is meant by an induction coil and draw sketch.
9. A certain coal contains 10% moisture and 10% ash when taken from the mine. What per cent. ash does it contain when dry?
10. A certain hydraulic ram, 6 ins. in diameter has a pressure of 100 lbs. per sq. in. acting upon it. What will be the intensity of the pressure on the plunger, 3 ins. in diameter?

Write an essay of not less than 500 words on some universal testing machine used for tensile, compression, and transverse tests. Explain how machine works and give drawings of the machine.

Mechanics and Dynamics of Engineering.

1. In a structural column composed of two channels with the flanges turned in, figure the least distance from back to back of the channels. Assume the necessary data and neglect effect of all lattice work.
2. Figure the least radius of gyration of a T-iron whose width is (b), depth (d) and thickness (t).
3. Explain and draw sketches of two kinds of friction brakes for engines.
4. Assuming the necessary data, determine the horsepower of a steam engine.
5. Explain and give sketches showing how you would design and attach two different indicator rigs to a steam engine.

Testing of Structural Materials.

1. Describe the instruments that are used and computations necessary to determine position of neutral axis in a reinforced concrete beam.
2. Describe the various methods and apparatus in use for mill inspection of structural steel.
3. Give and discuss all the various causes affecting the strength of concrete.
4. Name the various methods which you would use in determining the value of sand, gravel, or broken stone for concrete.
5. Discuss the effects on physical properties of steel of (a) the temperature on leaving the rolls, (b) cold working.
6. Give the method that you would use to determine proportions necessary to obtain the maximum density in making concrete.
7. Give the methods that you would use in determining physical properties of (a) brick, (b) stone.
8. Explain and discuss factors of safety allowed for steel and concrete in a structure of reinforced concrete.
9. What is the effect on physical properties when steel is stressed a little beyond its elastic limit but far below its ultimate strength.
10. What is the effect of a very high temperature on (a) cement, (b) stone, (c) metal.

Further Comment on the Minneapolis Building Department Tests of Concrete Columns.

Sir: In view of the fact that the column tests at Minneapolis, as reported in your paper of December 3, 1908, p. 608, are liable because of the small size of the specimens to lead to divergent conclusions, a few remarks with reference to them may not be out of place at this time.

1. It is evident that the columns were all smaller, being only 9 ins. square, than is considered good practice in practical construction, because of the difficulty of properly placing the concrete around the reinforcement.

2. The tests of columns with flat bands, A, B and C, in comparison with the columns E, D and F, indicate that the wide bands affected the placing of the concrete, separating the internal core from the outside shell so that it would have been nearly as accurate to base the strength upon the material within the bands, that is, upon a section of 38 sq. ins., instead of upon the total area of 63 [81?] sq. ins. This set of tests, A, B and C, is therefore inconclusive except as showing the practical difficulty in the use of bands in small columns, and the necessity for disregarding all concrete outside of the bands when computing the strength.

3. The six columns E, D and F, each of which contained eight ⅝-in. rods, are the only ones which are a fair test of columns longitudinally reinforced, since they are the only specimens except the plain columns in which the small sectional area was not cut by bands or hoops. Taking these columns, we find an average strength 38% in excess of the plain columns, whereas, with the percentage of reinforcement used, the ordinary formula for vertical steel (using a ratio of elasticity of steel to concrete of 15) gives 34% as the increase which might be expected. In other words, the actual strength of this set of columns was in excess of the theoretical strength. The wire bands on these columns could not be considered even by the advocate of hooped columns as appreciably adding to the strength, because they were square instead of circular. It may be noted further in connection with these longitudinally reinforced columns that the results were very uniform and, further, that the strength of *every specimen* was much greater than the strength of the plain columns, being in every case except one at least 40% greater. In these columns the rods buckled between the bands, but they evidently did not do so until their elastic limit was passed, at which time of course they would be expected to fail.

4. With reference to columns A, B, C and L, which were essentially hooped columns, the failure appears to have been caused by the greater deformation which is always found in hooped columns, and which in the earlier stages of the loading is apparently due to lack of homogeneity caused by the difficulty in placing the concrete around the hooping, and in the later stages of the loading to the excessive expansion of the concrete. This greater deformation in a hooped column causes any vertical steel to pass its elastic limit at an earlier stage than in a column where the deformation is less, and therefore produces the buckling between the bands which is noted in these two sets of columns. This excessive deformation is a strong argument against the use of high working stresses in hooped columns.

In conclusion, then, it may be said that the columns reinforced with vertical round rods showed all the strength that would be expected of them by theoretical computation. The hooped columns, on the other hand, that is the columns reinforced with circular bands and hoops, gave in all cases comparatively low results but no conclusions can be drawn from them because the unit-strength would have been greatly increased if the columns had been larger so that the relative area of the internal core to the total area of the column had been greater.

Yours very truly,

Sanford E. Thompson.

Newton Highlands, Mass., Dec. 22, 1908.

Sir: Referring to the results of tests upon reinforced concrete columns published in the Engineering News of Dec. 3, 1908, I have to say that during the past three years we have tested in all about 60 columns, reinforced in the various ways practiced by engineers, architects and contractors operating in the city of Minneapolis. The money for this work was appropriated by the City Council, and I can assure you it was exceedingly nominal; so nominal, in fact, that it was impossible to make a sufficient number of tests of each system of reinforcement to make a definite deduction from which to develop a rational formula for these various types. However, we consider these tests of great value, in that they show conclusively the necessity of unusual discretion, horse-sense and practical judgment on the part of the engineer in designing this class of work.

They show that riveted or electrically welded bands used as hoops cannot with any degree of surety be assumed to fulfill the functions of the continuous spirals, computed as imaginary longitudinals taken as 2.4 times that of the hooping metal.

They show the folly of using an excess amount of metal as longitudinals.

They have demonstrated to an absolute certainty that the longitudinals get an initial compressive stress due to the shrinking of the concrete in setting.

They show the necessity of the aggregate being nominal as to coarseness.

They show the necessity of a rich dense mix.

They show that the core area only should be assumed to take the compression loads and that the concrete outside of the core area is fit only as an insulation against fire.

They show the necessity of well-secured and tight forms.

They show that however careful the designing engineer may be in the use of his theories, errors are bound to creep in, in the construction, at the job; that is to say, the steel may get out of center, and in the spacing of the spirals or hoops there is a likelihood of the hoops bunching or the spirals springing away from each other at a splice; and, it is not unusual for a batch of aggregate to get into the column without any cement in it at all, in which case the column must be patched afterwards, and here we have demonstrated that the new patch in setting up shrinks away from the older parts, leaving a hair space between them.

And finally they show that the most economical and ideal reinforced column is the column reinforced with a spiral, which has a volume, when assumed as imaginary longitudinals taken as 2.4 times the hooping metal, equal to 3% of the core volume when high carbon steel is used and 4½% when mild steel is used; viz:

$$\% = \frac{(\text{Area of hooping metal}) \times (\text{length of helix}) \times 2.4}{\text{Volume of core}} \times 100.$$

the pitch of the turns not exceeding 15% of the core diameter and 1¼% of metal used as longitudinals. This longitudinal metal is used not so much for its intrinsic value in taking direct compression, but more especially for stiffness.

In conclusion, I wish to acknowledge the able comment on these tests by the editor of the Engineering News, and also those of Mr. Edw. Godfrey in your issue of Dec. 17, 1908.

Yours truly,

Wm. P. Cowles,

Engineer for the Department of Buildings for the City of Minneapolis.

City Hall, Minneapolis, Minn., Dec. 23, 1908.

[As the conclusions above stated by Mr. Cowles do not follow from the 17 tests reported in our issue of Dec. 3, we assume that the remaining

tests of the 60 are the basis for the conclusions. However, if these 43 other tests point to this or that positive conclusion, yet they cannot overthrow the negative conclusions derived from the 17 tests reported. Thus, while Mr. Cowles finds, in the entire 60 tests, reasons for condemning pure longitudinal reinforcement and for regarding mixed reinforcement as ideal, Mr. Thompson finds that the 17 tests show the hooped columns inferior. This throws a strong doubt, to say the least, on the positive conclusion in favor of the hooped column, since consistently low results may be just as good as if not better than erratic results which average higher. The greatly variable results in the 17 tests reported need explanation, at any rate.

As to how far the small diameter may serve to explain the matter, as Mr. Thompson holds, we leave to the judgment of those skilled in the art. But we believe that in view of the extensive use of concrete thicknesses less than 12 ins., in reinforced concrete construction, a type of reinforcement which proves unpractical or treacherous in a post 9 × 9 ins. by 9½ ft. long cannot claim unqualified approval.—Ed.]

The Stress Calculation for the Blackwell's Island Bridge.

Sir: Your editorial comment on my letter (Engineering News, Dec. 17, p. 679) obliges me to beg your attention for some additional remarks in order to remove the apparent misunderstanding largely due I must confess to the shortness of my previous remarks.

I stated that this repeated calculation of reflections was the wrong way to do and that a line of deflection for a unit load at the rockers should have been drawn. With this I don't mean to say that this should have been done by means of a Williot displacement diagram, which would be too unexact in this case, and would not allow a division of labor. You seem to suppose that a numerical solution necessarily involves the repeated calculation of the deflections at the rockers for a load=1 at every panel point and that thus in no way superfluous labor should have been done; that "the only shortening of work attainable was reducing the number of different loadings, accomplished in the method pursued by Boller & Hodge." Such, however, is not the case. This repetition might have been avoided and a pile of labor cut out by the selection of the proper method.

The usual way to figure out deflections, in case a few deflections are wanted, is the one based on the principle of virtual velocities, and I guess it's the one used by the experts. Bridge engineers use it as a rule to check up a few deflections out of a large number, obtained by a displacement diagram, in order to test the degree of exactness of the drawing. It is based on the formula

$$d = \Sigma \frac{S' Sl}{E F}$$

In this case it requires for every deflection a good sized sheet full of figures. For every sheet a new set of stresses S is necessary, the other, S', serving for all. For the whole bridge a large number of such sheets are necessary. As a rule $\frac{1}{E}$ can be taken before the Σ sign; here we have a subdivision since $\frac{1}{E}$ is not constant [?]. Application therefore, on the calculation of a deflection line for a Queensboro bridge results in a big pile of work, and therefore we find in the textbooks of applied mechanics the remark that in such cases it becomes too laborious and other methods have to be chosen. I certainly am aware that the deflections in other points don't result out of it incidentally, and that's just the very reason why we want a method which gives all those deflections in one operation.

In its place comes then the simple and ingenious method of Müller-Breslau, referred to by me before. This method is not altogether new (my edition of "The Newer Methods of the Elasticity Theory" is of 1893) and is known among bridge engineers. It is based on the same principle as Mohr's construction of the elastic line and gives the deflections as ordinates of a moment polygon computed, in the case of a straight bottom chord, with the chord angle variations $\Delta\delta$ as loads. These $\Delta\delta$ are computed from $\frac{1}{E}\Sigma\ (s_a - s_{a+1})\cot\alpha_a$ and the quantities we need are, first, one set of stresses, and second, one set of cotangents of the angles between the members obtained in our case for the greater part by mere division and for the others scaled off or computed from the sides. The quantities $\Delta\ \delta$ obtained, the deflections follow by simple addition and multiplication by the panel lengths. A test will show the radical difference in the amount of work between both methods which, in case the bridge is composed of a large number of members, becomes enormous.

Now this method, combined as I stated with the choice of the reactions of the two middle supports as redundant quantities, would be the thing to do in this case, and could be divided up in every way to enable a large force to work on it.

I would start this bridge with five independent divisions. The first to compute the lines of influence for the stress in every member, two supports removed and for a moving unit load. The second to compute the "influence-factor" of the two redundant reactions for every member. The third to compute the unit-stresses in every member, two supports removed and at the first removed support a unit-load. The fourth to compute the same, at the second removed support a unit-load. The fifth to compute the cotangents of the angles between the members. Very soon the first results from 3-5 and 4-5 combined enable to start a sixth and seventh division to figure out the $\Delta\delta$ for a unit-load at the first, and a unit-load at the second removed support—for every panel-point. An eighth and ninth to compute the deflections and final values for reactions at removed supports for moving unit-load; 8 and 9 can begin while 3 and 4 are still working. The results of 8, 9, 2 and 1 combined give the final values of the stresses in the members for a moving unit-load. Now every one of these divisions can be composed of more calculations, each getting a certain number of panels.

But I understand that you supposed me to propose a graphical solution, which would not allow such a procedure. Not, as I said, by using the Williot displacement diagram applied in the usual way on structures with a smaller number of members. Here, however, the displacement diagram is very appropriate if applied to construct the $\Delta\delta$ and such can be done with a high degree of accuracy. Then the chord polygon representing the deflections can be drawn very well with an error not over 3%. Now these graphical solutions of $\Delta\ \delta$ by a Williot diagram can be worked at quite independently for every panel of the bridge.

Considering the remark on page 557 of Eng. News that Prof. Burr finds one member overstressed 33% [obviously an error on the part of Prof. Burr; we are informed that the two stress sheets checked absolutely.—Ed.] and Boller and Hodge several members 45-47%, which would indicate a difference of ± 9-13% between the two in several instances, I think that's a pretty big difference and should not be passed unnoticed. The method used by Prof. Burr was not published and it would be very interesting to know. A difference of 9-13% could very well be equalled if not surpassed by a graphical solution in the way indicated, and taking a good deal less time. I am,

Very truly yours,

A. Streiff, C. E.

45 Clinton St., Newark, N. J., Dec. 20, 1908.

Sir: I am glad to see you so forcibly take up the defense of simple methods in bridge calculations in your discussion of the letter written by Mr. A. Streiff, published in your issue of Dec. 17, 1908. Mr. Streiff's proposal to leave these matters in the hands of engineers "whom nobody is competent to criticize" is apt to lead us (or our bridges) into "deep water."

Because there is a very hard way to solve a problem in structural stresses does not prove that it is a better way than one vastly more simple and more easily understood and carried out in easy stages capable of being readily checked. If admission to the mathematical heaven is solely by the austere methods of some books that could be named, there will be a lot of us that will not get more than a chance to look in, who have committed the unpardonable sin of using short-cuts.

High authorities are good, if their work is found to be correct. Mr. Robert A. Bruce in "American Machinist," April 20, 1899, in an article on springs says: "The author has discovered that a series of curious errors with respect to the torsional strength of square sections have a common origin in a mistake made by Rankine and copied time after time by other writers." Here appears to be an error of one of the world's most revered authorities—England's greatest in the engineering field.

Mr. Streiff mentions Euler as one of the "saints." Euler's column formula is said to give the load at which "the column just begins to deflect, and will under a constant load retain any deflection which may be given to it, within the elastic limit" (Johnson's Framed Structures). I find that the load of Euler's formula is one that will cause ultimate failure in any column not absolutely perfect, no matter how high the elastic limit of the steel of which it is made.

Yours very truly,

Edward Godfrey.

Monongahela Bank Bldg., Pittsburg, Pa., Dec. 21, 1908.

Concerning the Proposed Passaic Valley Trunk Sewer Outlet into New York Bay.

Sir: In your issue of Dec. 17, 1908, there was an editorial commenting upon the recent hearing before the Harbor Line Board in relation to the proposed Passaic Valley sewer. I have read this article with very much interest, but feel that I must take exception to some portions of it as not being in accordance with the actual developments at that meeting.

In one portion of your article you state that apparently the opposition emanates from only a few enthusiasts and is not backed by any of our commercial organizations or influential bodies in this city; and, therefore, you draw the inference that the City of New York does not seriously oppose this sewage plan. In reply to this portion of your statement, I beg leave to call your attention to the fact that Mr. Higgins appeared on behalf of the Chamber of Commerce, which body unanimously voted to express its strong disapproval of this scheme. He also appeared for the New York Board of Pilots, who are vitally interested in maintaining a deep channel for the accommodation of all steamship traffic coming to this port. Dr. Soper appeared for the Metropolitan Sewerage Commission, stating that this Commission was investigating the whole subject with a view to ultimately doing away with the dumping of sewage from New York and Brooklyn into the river and harbor. Dr. Porter appeared on behalf of the State Board [State Department of Health.—Ed.], also strongly objecting to the proposed plan. Dr. Darlington appeared for the Board of Health [New York City Department of Health.—Ed.], pointing out the injurious effects of sewage on the health, and that any addition to the present volume of sewage would only increase the danger still further; he was very emphatic in his views on this subject, and having had large experience, spoke with authority. Captain Parsons appeared on behalf of the Maritime Exchange in the interests of sailing vessel trade of this port. There were various representatives of real estate associations and building companies, all of whom were strongly opposed to the sewage proposition. I appeared on behalf of the New York Produce Exchange and the steamship interests, as well as all the trades that are gathered in our Exchange. As stated at that meeting, we are vitally interested in that matter. The steamship companies all desire as great a depth of water as possible for the large steamers now coming to this port and the larger ones building and to be built, and every facility will be needed to care for them when they come here. The New York Produce Exchange being located at the extreme lower end of New York City is also vitally interested in this question, as the large membership is congregated in offices, many of which border on the river front, and they are affected by this sewage discharge.

I think you must agree with me that the varied interests of New York were strongly represented at this meeting, and they all opposed the plan with every argument in their power.

You go on to state that any tyro should readily understand that this sewage would quickly lose any unhealthful effects when it comes in contact with the flow of the tides. As to this, I am not a scientist and cannot reply, but it does not seem reasonable that the salt water should render this foul discharge perfectly healthful.

You also state in your article that there has been no disposition shown by this State to try to meet the residents of New Jersey on any reasonable basis and plan. Again I must differ with you, because there have been two separate requests made by our authorities to the Governor of New Jersey that a commission be appointed to confer with the Metropolitan Sewerage Commission, having in view the adoption of some plan that would be mutually satisfactory.

Your article bears so strongly in favor of this plan that I can hardly believe you are looking at the interests of New York City in a fair and reasonable light. Why New Jersey should have the privilege of bringing its sewage from long distances and dumping it before our doors is something that we in New York cannot understand and certainly do not agree to.

If, as the plan claims, they can render this sewage entirely healthful, and the screening process takes out practically all of the solid matter, so that there would be no danger on account of the health, and the grit or silt would not fill up the harbor, then why is the State of New Jersey so unwilling to permit the dumping of this sewage into the mouth of the Passaic River or into Newark Bay? If it is a bad thing for New Jersey, it certainly is a bad thing for New York.

There is no necessity for carrying out this plan, as under modern systems of sewage disposal it can be readily cared for, and after a plant is established the solid portion can be sold as fertilizer and soon becomes a revenue producer. This has been clearly demonstrated in many instances, and it certainly can be applied to the cities along the Passaic River. I do not think in this enlightened age we should cling to the old methods, but rather adopt new ones that are more suitable to our modern conditions.

I am writing you this letter as I desire to protest on behalf of our Exchange and its allied interests against the tenor of your editorial, and as your paper meets with a large circulation and has spread abroad these incorrect statements, I trust you will publish this in fairness to the New York side of the question.

I remain, dear sir, Yours very truly,

Welding Ring,

President New York Produce Exchange.

New York City, Dec. 22, 1908.

[We regret that our correspondent appears to have quite misunderstood our attitude on this

subject. Instead of saying that opposition to the proposed sewer outlet is confined to a few enthusiasts and lacks the support of commercial organizations we remarked that New York City is taking no official steps to stop its own pollution of the harbor, and that such activities as there had been against the New York pollution (not the proposed discharge of sewage from New Jersey) were nearly all "due to the zeal of a mere handful of enthusiasts acting in their private capacity."

As to our "tyro," we did not march him across the argumentative stage to emphasize any assertion that sewage discharged into New York harbor "would quickly lose any unhealthful effect when it comes in contact with the flow of the tides," to quote Mr. Ring, but merely to reinforce our argument "that, oysters aside, the danger to the public health from sewage so discharged and diluted would be so remote as to deserve no consideration until a hundred worse dangers had been removed." Our whole thesis in this connection was that sewage disposal into New York harbor had only a remote relation to the public health, and that such present and prospective danger as now or may hereafter exist appertains to the haphazard sewage disposal of New York City, which thus far is quite innocent of "method," and not to the scientifically worked out scheme of the Passaic Valley Sewerage Commission.

We made no reference whatever to there having "been no disposition shown by this State [New York] to meet the residents of New Jersey on any reasonable basis or plan" (fifth paragraph of Mr. Ring's letter).

As to our not "looking at the interests of New York City in a fair and reasonable light," our endeavor was to be fair and reasonable to the whole metropolitan district, of which New York City is only a part. But if the questions at issue concerned the New York and New Jersey metropolitan district alone we would hardly be warranted in giving much space to them, in view of the fact that by far the greater part of our readers are scattered through other States and countries. Our chief concern is to ascertain and disseminate the truth as regards engineering matters, be they sewage disposal or otherwise.

The truth here is that sewage disposal by dilution is just as scientific and just as legitimate a practice as by any other means, provided conditions are favorable, and that they are so very favorable in this case that any other method than disposal by dilution would be considered by most engineers as a sanitary and economic wrong.

The statements in the last paragraph will serve as an answer to the questions in the sixth and seventh paragraphs of Mr. Ring's letter. There is not water enough in Newark Bay, the future considered, to dilute the sewage of the Passaic District, and there is water a-plenty in New York Bay (to which Newark Bay is tributary) to dilute the sewage of the whole New York and New Jersey metropolitan district for many years to come—provided measures suited to the peculiar local conditions of each sub-division of the district are carried out, as is proposed for the Passaic District.

In the next-to-the-last paragraph of Mr. Ring's letter he treads on dangerous ground for one who is not thoroughly conversant with the principles and practice of sewage disposal—and he has previously disclaimed being a "scientist." Of course the sewage of the Passaic cities and towns could be treated so as to produce almost any sort of an effluent desired, provided expense was no consideration and a suitable location for disposal works could be obtained, but after careful investigation capable engineers have declared that disposal by dilution in New York harbor would be cheaper and that it can be effected without detriment to any interests concerned. As to getting a net revenue from sewage, we doubt whether that has ever been achieved throughout the whole history of any sewage disposal plant where purification rather than irrigation (in arid regions) was the object, and was attained. Possibly a few instances could be cited, where local conditions were highly favorable. For the New York metropolitan districts local conditions for gaining net revenues are not only unfavorable but the obtaining of any considerable revenue whatever would be impossible, under present conditions.

As to recovering the solid matter from sewage and selling it for use as a fertilizer that has never yielded a net profit anywhere and has been given up pretty generally wherever it has been tried.

We have replied to Mr. Ring at considerable length because of the important official position which he holds and the evident earnestness in opposing the proposed sewer outlet which has been shown both by him and other representatives of commercial organizations in New York City.—Ed.]

Further Plans for Grade Crossing Removal at Toronto, Can.

Sir: The Board of Railway Commissioners has stated its intention to issue an order upon Jan. 13 directing the Grand Trunk and Canadian Pacific Railway Companies to submit within 60 days "a plan showing at least four tracks of railway elevated and carried over the streets now open in the city between York and Cherry Sts., both included." The Board will also order "that within two years from the approval of the said plan by the Board the railway companies shall alter and arrange their yards and sidings so that no tracks on ground level shall cross York, Bay, Yonge or Church Sts." The order will further prescribe certain limited operation of tracks at grade over other streets, and that the cost of all structures called for by the changes to be ordered shall be divided between the railways and the city in the proportion of ⅘ and ⅕.

While this order calls for a viaduct or for elevation of tracks it is a very substantial modification of the plan proposed by the city as outlined in my letter of Dec. 21 (Eng. News, Dec. 31, 1908, p. 752). Three tracks are now required for through trains, two for the Grand Trunk passengers and freights and one for the Canadian Pacific passenger trains; its through freights now pass over the line two miles to the north of the waterfront. With any substantial increase in business the four elevated tracks will all be needed for passenger trains. The local freight yards and industrial tracks will be retained at grade, excepting that they must be abolished crossing the four streets above referred to. The effect of this part of the order will be to cut the local freight terminal into two yards, one west of York St., the other east of Church St., the interval being a little less than half a mile. Within this space access will be had by subways to the waterfront with the greatest freedom.

Separate opinions were written by the Chief Commissioner, Hon. J. P. Mabee, and by the Assistant Commissioner, Hon. D'Arcy Scott. Hon. James Mills concurs with the opinion of Commissioner Scott. Mr. Scott discussed the question at considerable length and with great fairness. Judge Mabee's opinion is more brief and his language indicates that he has in mind what Mr. Scott does not refer to—the possibility of a radical change in location—for he says, "Now if these terminals are to continue on the waterfront and the streets cannot be conveniently carried over the railway tracks, it is apparent that the latter must be carried over the streets if grade separation is to be accomplished."

The statutory clearance in Canada is 22 ft. 6 ins., and the Board decided that they could not modify this height, which fact largely determined their judgment in rejecting the plan of street bridges. I am informed that interested parties will be heard again on the date that it is proposed to issue the order when they may ask for modification.

Yours very truly,

"Viaduct."

Toronto, Canada, Jan. 4, 1909.

COAL VS. OIL-GAS.—An interesting note concerning the relative economy of coal and oil firing is found in the annual report of the Chief of the Bureau of Equipment, Navy Department, for 1908. In making report for the navy yard at Portsmouth, N. H., it is stated (p. 8) that the rolling mill, anchor and chain shops are now using coal instead of oil as fuel in the heating furnaces and forges, with considerable saving, the gases from the furnaces being led under boilers to produce steam for the hammers:

> The waste heat boilers installed over the reheating and bar furnaces have been in successful operation during the year. These boilers supply steam for the hammers, and the direct saving in fuel has been 1,598.10 tons of coal for the year.
>
> The use of naphtha distillate for the manufacture of gas for forge fires has been discontinued, the last fire using gas being on March 10, 1908.
>
> There has resulted a saving of $11,935.25 for the year by the substitution of coal for gas as a fuel and the use of the waste heat boilers, although naphtha was used for seven months on a decreasing number of fires.

A Novel Reinforced-Concrete Tower and Tank.

By R. B. TUFTS.*

The accompanying figures show a reinforced-concrete tower and tank, recently built for the Atlantic Compress Co., Atlanta, Ga., which embodies novelties of design that may be interesting to the profession.

As will be observed from Fig. 2, the structure is essentially a hollow chimney-like shaft, 30 ft. inside diameter at the ground and tapering to a truly cylindrical 22 ft. inside diameter at a point 90 ft. above the ground, and supporting a cylindrical tank of 100,000 gals. capacity. The tank bottom is a spherical arch and is self braced by

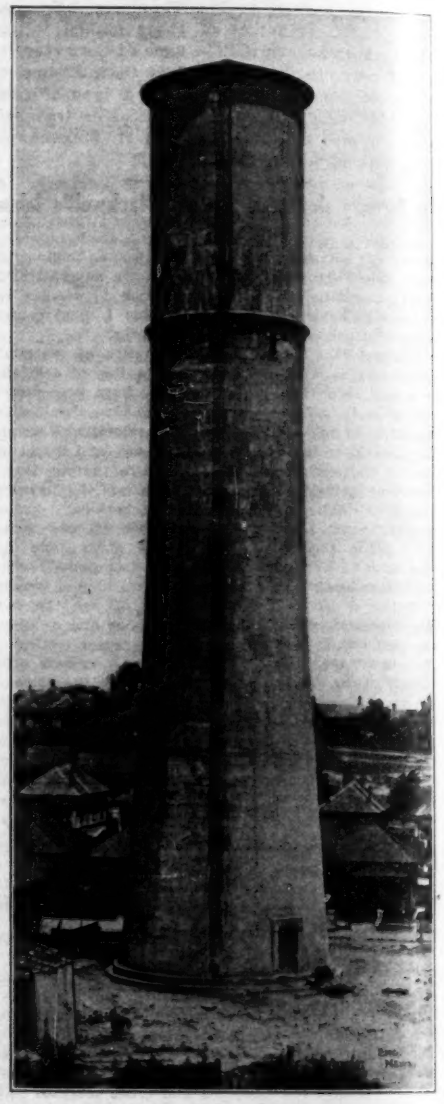


Fig. 1. A Reinforced-Concrete Tank Supported by a Hollow Shaft.
(Built for the Atlantic Compress Co., Atlanta, Ga., by the Piedmont Construction Co.)

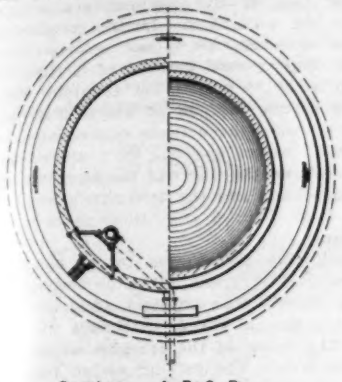
virtue of its convex or dome shape. Properly to support the bottom, where it unites with the shaft, a projecting ring is formed on the inside and an ornamental cornice on the outside, the two combining to give the wall of the shaft greater thickness at this place. In this thicker portion of the wall are embedded 14 complete rings of ⅞-in. square bars, each ring being made up of separate bars, properly curved and lapped 4 ft. at joints, so as to act like continuous hoops, retaining the spherical arch and keeping it from spreading under the heavy superimposed load of water.

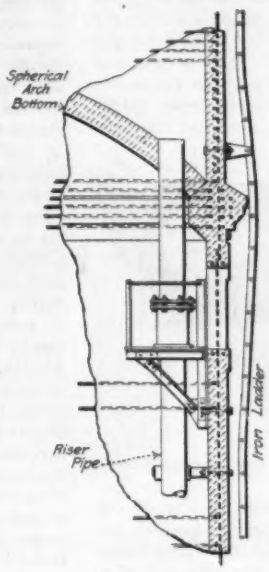
The tank shell is reinforced by having embedded ¾-in. bars properly curved and lapped and laid in horizontal courses varying in ver-

*Vice-President and Manager, The Piedmont Construction Co., Atlanta, Ga.

ical pitch from 3-in. centers near the bottom to 12 ins. near the top. The convex bottom is reinforced with ½-in. bars placed in about 18-in. squares. The shaft below the tank is reinforced with ½-in. bars laid in horizontal courses on 12-in. centers and with ½-in. bars placed vertically on 3-ft. centers, with special reinforcement around each window and door opening.

The thickness of the shaft wall is 19 ins. near the ground and diminishes to 8 ins. where the tank is formed and 6 ins. near the top of the tank. The spherical arch bottom is 10 ins. thick.





Details of Base of Tank. (Enlarged.)

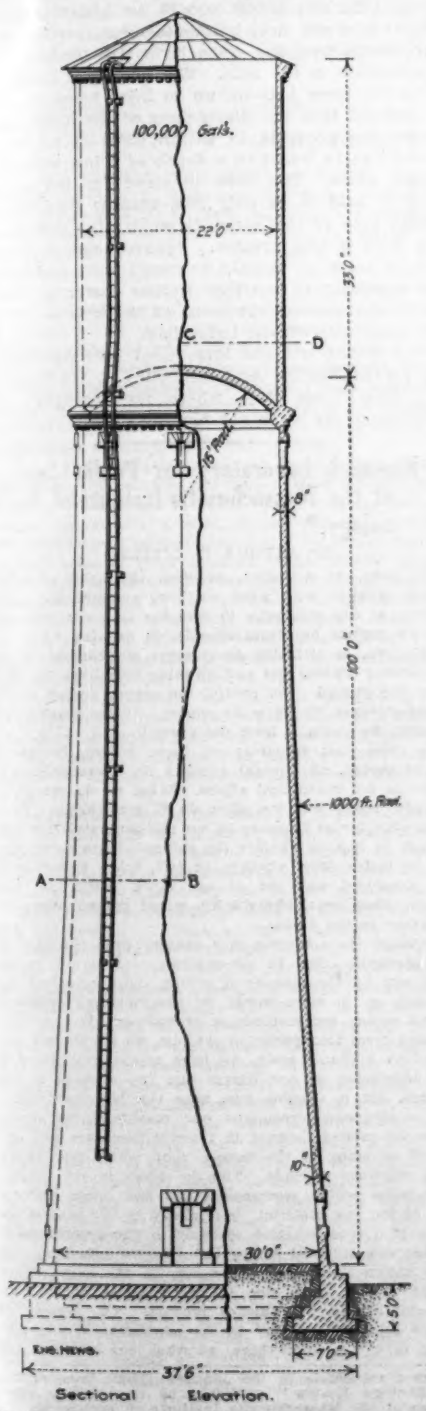


Fig. 2. Details of Reinforced-Concrete Tower and Tank, Atlanta, Ga.

One novel feature of the structure is the character of its taper. Instead of tapering uniformly from the ground up, the taper is such as would be generated by an arc circle of 1,000 ft. radius revolving about a vertical axis, the arc being tangent to a vertical line at a point 90 ft. above the ground. The effect of this taper is to make the structure resemble a lighthouse and it is thought to be more pleasing in appearance than if the taper were uniform.

The tank is plastered inside with 1:1½ cement mortar and on the inside of this plaster was applied three coats of Trinidad asphalt dissolved with gasoline until quite thin. This asphalt penetrated into the pores of the plaster and gave it a glazed finish. Great reliance was put in this asphalt coating as a waterproof lining, but subsequent investigations have led the writer to believe that this asphalt plays very little, if any, part in making the tank watertight.

All scaffolding was done inside the structure and the concrete was handled from the mixer in small pails placed on the elevator platform and hoisted by a gasoline engine. The forms were especially designed for this class of work and consist of flexible sheet iron members assembled with alternating wooden members into complete inner and outer rings. Three courses of forms were used each 3 ft. deep. When one course was removed, member by member from its position below, the alternate wooden members would be altered by taking out the proper wooden strip so that when reassembled into a ring above the concrete last laid, the resulting inner and outer rings of the forms would have the right circumferences at the top and at the bottom to develop a ring of the structure of desired dimensions. In this way the taper of the structure was effected by making the shaft a series of frustrums of cones, each 3 ft. high, the slant of each ring being slightly less than the ring immediately below.

The roof for convenience is No. 14 gage iron, though hereafter like structures will be provided with concrete roofs.

The entire shaft was finished, the roof placed and painted and the tank shell waterproofed inside before the bottom was placed. After removing the inside scaffolding to a point sufficiently low, the centering was placed and the spherical arch bottom molded, leaving an 18-in. hole in the center for passage of workmen and material. After this bottom had partly hardened, plaster was pulled up through the hole and the bottom was given a coat of 1:1 cement plaster, after which a few buckets of mixed concrete were taken up through the hole, the hole plugged and the man then came out of the roof and down the ladder to the ground.

After the last concrete laid was about a month old, the tank was filled. At first it leaked a little near the bottom, but the pores were rapidly filled so that in a few weeks' time the tank became practically tight. All leaks reduced to two or three points from which occasional drops fell except one place, which showed a little fissure in the walls. The water was turned off and the locality of this fissure on the inside was plastered with two coats of neat cement. After it had hardened a few days, the water was turned on again with the result that this place was entirely tight.

The fact that the tank leaked at first near the bottom, led the writer to the conclusion that the asphalt coating is of no value for waterproofing. He is convinced that the plaster lining is doing most of the work assisted by the rich wet mixed concrete in the tank shell. On other similar jobs he expects to make the tank of a very much richer concrete and to plaster inside with neat cement.

Instead of crushed stone, a smooth pebble was used in the concrete which gave better results than could generally be gotten with crushed stone. In this foundation the mixture was 1:3:6, in the tower 1:2½:5 and in the tank 1:2:4. All concrete was mixed mechanically, just wet enough to pour and to be puddled, but not enough for the ingredients to separate.

In examining the structure for stresses developed, the maximum compression in the concrete occurs at the ground line and amounts to only 192 lbs. per sq. in., for the weight of structure and water, while the assumed wind pressure develops a compression here of 62.6 lbs., making the total maximum compression in the concrete only 254.6 lbs. per sq. in. of cross section. Inasmuch as this class of concrete usually has an ultimate unit compressive strength of about 2,500 or 3,000 lbs., it is estimated that the factor of safety in the concrete is probably not less than ten. All reinforcement is proportioned to take only 12,000 lbs. per sq. in. of cross section, allowing no tension to be taken by the concrete. This low figure was taken in the hope of avoiding cracks due to excessive elongation of the steel. In designing the structure an assumed wind pressure of 25 lbs. per sq. ft. of projected area of the cylindrical surface was assumed to act uniformly on the structure.

The ground is the hardest red clay, and the dead load pressure is 3,500 lbs. per sq. ft., which is augmented by the assumed wind pressure about 1,000 lbs. per sq. ft., making the total earth pressure about 4,500 lbs. per sq. ft. No visible settlement has taken place.

The tank has been constantly full for nearly a year now and is an entire success. At the present time there is being constructed for the water-works of Belton a reinforced-concrete tower and tank somewhat similar in design to the one here described, but of a capacity of 150,000 gals., and 150 ft. to the upper water surface.

It is proposed to make a practice of planting climbing ivy at the bases of the structure, which in a few years will cover them, and it is thought will make them very artistic without in any way effecting their permanency. It will be observed that a comparatively large circular chamber is formed in the base of the structure which will generally be found very valuable for storage purposes, while in some cases it can be used as a pump house. Also, the riser pipe, being inclosed in the air-tight chamber, will require no frost proofing. The window openings have heavy glass cemented in them, thus affording light to the interior of the shaft and at the same time making it air tight.

The structure was designed and given general supervision during construction by the writer of this article. It was built by the Piedmont Construction Co., of Atlanta, Ga. Mr. H. B. Johnson was engineer for the Compress Co. The cost of the structure, including the foundation, was about $6,000 complete, approximately the same as the estimated cost of the steel structure, including the foundation.

The Creosoted Pile Bridge from Galveston Island to the Mainland.

As noted in a recent issue of Engineering News, a causeway for joint railways and highway use is shortly to be built from Galveston Island to the mainland. At present all the railways entering Galveston pass over a single-track viaduct about 11,000 ft. long supported on creosoted piling and over 4,000 separate piles. The growth in the traffic over this structure is illus-

trated by the figures in the following table, showing the number of cars passing over it each year for a period of seven years.

Year.	Number of cars.*
1901	247,118
1902	245,422
1903	320,116
1904	293,454
1905	329,402
1906	349,942
1907	352,532

*Each locomotive is figured as three cars.

The following statement regarding this bridge and the piling used in it has been received from the International Creosoting & Construction Co., of Galveston,, Tex., which furnished the piling for the bridge in its original construction:

The piles used in the Galveston bridge were all of Southern pine treated with 24 lbs. of anhydrous creosote oil per cu. f. They were practically all green when treated, most of them coming direct from the stump and being seasoned by steaming with the same process and methods as are now in use by that company. As is the case with thoroughly impregnated piles, they would sink if allowed to fall in the water, an experience which cost the pile driver several sticks of piling.

At the time when this bridge was built, there was some disbelief in the durability of creosoted piling, but the International Creosoting & Construction Co. were so completely certain of the lasting qualities of their own work that they gave a ten-year guarantee on the bridge in question, agreeing to replace any stick of piling, which at the end of ten years showed any traces of decay or deterioration of any character. The bridge was built in 1895. In 1905, when the official inspection was made in anticipation of its final acceptance, not one stick of piling had to be replaced. This condition of affairs was exceedingly satisfactory to all concerned, first to the treating company as proof of its own successful work and secondly to the railroad company as an evidence of the fact that creosoted piling when honestly and thoroughly treated are safe from the teredo and that a railroad built on such a structure is not a menace to the lives of the people who travel over it daily.

Early this year there occurred the lowest water in years in the bay between Galveston Island and the mainland. The water was so low that two-thirds of the total number of piles were exposed to the mud line. This afforded opportunity for a most complete examination of each pile and the official report of this inspection showed that not one pile originally furnished by the International Creosoting and Construction Co. was in any way decayed.

This good record of creosoted piling should interest those engineers who from many instances of the failure of such work are in doubt as to the reliability of creosoted piling for marine construction.

There were three things that were of special importance in treating the piling for the Galveston bridge:

First, the timber itself; it was freshly cut and consequently there was the minimum likelihood of any decay being present in the piling previous to treatment.

Second, a high grade of oil was used. It was a London oil of a good specific gravity, of an average amount of naphthalene and of a good percentage of anthracene oils.

Third, and most important of all, was the assurance that each charge of piling received the required amount of oil per cubic foot.

A Drill and Chuck for Boring Square Holes.

The present prevailing methods of making square holes in wood and metals involve in most cases a series of successive separate operations and are consequently slower and more expensive than those for round holes of like proportions. The accompanying illustrations show a device for drilling or boring square holes of the desired size and shape in one operation. This device has been in use in German machine shops for about two years, but has only recently been introduced into this country. The essential features are the three-sided drill and the special chuck which drives and guides it.

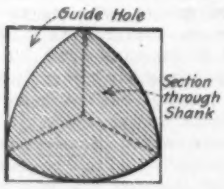


Fig. 1a. Diagrammatic Section Showing Principle of Operation.

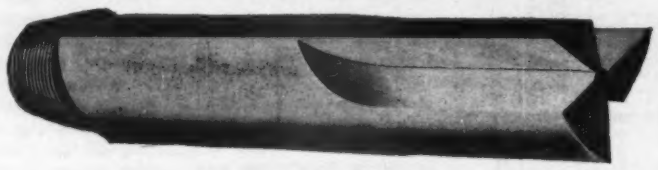


Fig. 1b. Perspective View of Plain Drill.

FIG. 1. THREE-SIDED DRILL FOR SQUARE HOLES.

The shape of the drill is shown in Fig. 1. A section through the shank would resemble an equilateral triangle, but each of the three sides would be, not a straight line, but the arc of a circle with its center at the opposite corner of the section. When this shank is made to turn in a square guiding hole, while any one of the three sides rolls or slides on one side of the guide hole the opposite corner of the shank must describe a straight line corresponding to the opposite side of the hole. This is made clear by the diagrammatic section shown in Fig. 1. It will be noticed that the drill of this form makes a hole with slightly rounded corners. Another model is made with the shank considerably larger than the drill and with one corner of the shank rounded in such a way that holes are produced with sharply defined square corners. The body of the drill is fluted in such a way as to give three cutting edges, or lips, at the cutting end which radiate from the center to the corners of the drill section. The lips are ground back from the cutting edge to give the proper clearance and are sharpened by grinding on the end faces only, so that the accuracy of the drill is preserved. A simple holder enables the grinding to be done on an ordinary emery wheel and by unskilled labor. A threaded tang is provided which screws into the driving member of the chuck.

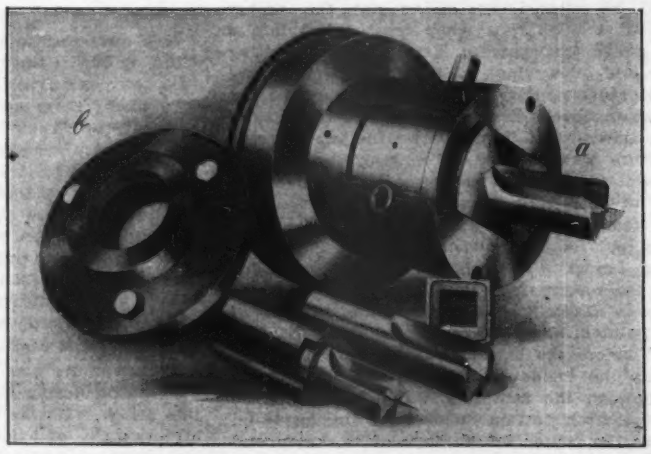


FIG. 2. CHUCK AND DRILLS FOR BORING SQUARE HOLES.
(Specimen near end of chuck shows hole made with enlarged shank drill and counterbored with plain shank drill of larger diameter.)

The chuck contains, in addition to the driving member, a guiding part which is held stationary while the rest revolves. The square guide hole is formed by two jaws with interlocking teeth, and the size of the hole is adjusted to fit the drill to be used by means of a right and left screw which moves the jaws toward or away from each other. The jaws are first opened wide so that the drill can be inserted in the guide hole and its tang screwed into the dog of the driving member; then the jaws are closed firmly upon the drill shank. The projection, or tail, of the dog engages with an opening in the wall of the driving member and serves to transmit the rotary motion to the drill. The dog is used instead of a rigid connection in order to permit the gyratory motion of the drill's axis, the end of which describes a small closed curve three times during each turn of the drill. Above the dog is a second loose piece which takes up the end thrust. The steel jaws of the chuck and the drill shank are hardened and it is claimed that there is no appreciable wear.

The chuck may be screwed to the spindle of any ordinary drill press, lathe or milling machine. In drilling iron or steel, it is necessary to provide a special clamp to secure the guide rigidly to the frame of the machine or the holes will not be true. The cutting action resembles more closely that of a milling cutter than of a twist drill, and better results are obtained with the axis of the drill horizontal than vertical for the reason that the chips have less tendency to accumulate in the hole. The drills are made in sizes for from 1/10-in. up to 2-in. holes, and it is claimed that the dimensions of the holes produced are accurate to within 0.001 of an inch. Holes can be bored to a depth of 4 ins. with the larger sizes. The time required for boring in steel is said to be only 20% greater than for a round hole of the same diameter; for cast iron the time is 15% greater. Square holes in brass can be made as quickly as round ones, and even more quickly in wood or similar material. The finish obtained on the walls of the hole is about the same as with the twist drill.

The device is being introduced into this country by the Radical Angular Drill Co., 114 Liberty St., New York City, where the machine and samples of its work are now on exhibition.

A Research Laboratory for Public Service at the Massachusetts Institute of Technology.*

By ARTHUR D. LITTLE.†

We have, as a nation, acquired the habit of being vastly satisfied with what we have accomplished. We marvel at our enterprise in scraping iron ore from the earth's surface by steam shovels, in growing wheat on virgin soil, in stripping great areas of primeval forest, in burning natural gas and allowing petroleum to spout from the ground. We control the copper market of the world—because we have the copper. If you want cheap sulphur we pump it from the ground.

To these vast resources we have, indeed, brought a native energy, an unusual capacity for organization and a genius for mechanical affairs. What we do, we do on a great scale, but we often do it very badly. It is quite time for us to pause in our self-congratulation long enough to inquire whether the things we are doing cannot be better done, whether, in fact, other nations have not developed and put to use much better methods, which, given equal opportunity, would put our own performance to the blush.

Although the resources of a country form the basis of its prosperity, this is, nevertheless, determined in the long run by the manner in which these resources are utilized, or, in other words, by the industrial efficiency of the means and methods of production. We have developed great transportation systems, we handle raw material on a titanic scale, we have applied machinery to the addressing of our letters and the sticking of the stamps, but it remains true none the less that with a few conspicuous exceptions our manufacturing operations are carried forward in trustful ignorance and disregard of many of the factors upon which real industrial efficiency depends. This is shown in the stupendous waste which accompanies the first crude preparation of the raw material; it is shown in the general absence of a true selective economy in the apportionment of that raw material among the different industries, and it is shown again, and yet again, in the losses which attend nearly every step in the progress of the raw material toward the finished product. The absence of proper selective economy in the adaptation of raw material to use is everywhere, as when our railroads use

*From an article in the January (1909) issue of the "Technology Review," published by the Alumni Association of the Massachusetts Institute of Technology.

†Chemical Engineer, 93 Broad St., Boston, Mass.

untreated ties and poles, when coal-tar is burned as fuel, crystal alum used for purifying water, or valuable publications printed on ground-wood papers. We are still polluting our streams with wool grease, still wondering whether we can make alcohol from waste molasses and still buying coal without reference to heating power.

When wastes so obvious and so easily remedied are everywhere taking heavy toll of our manufacturers, it is not surprising that in all lines of productive effort subtle and elusive problems present themselves and still further lower our industrial efficiency. Steel rails break by thousands; trolley wires snap; boilers corrode; milk cans rust; unsightly bloom appears on leather; cloth is stained; paints fail to protect the metal underneath. In a large proportion of cases those who are confronted by the problem have neither the time, the training, nor the equipment required for its solution and yet such problems and thousands of others far more complex upon their face must be solved if our industrial efficiency is to be brought to its proper level.

No one at all conversant with the facts can doubt that our industrial salvation must be found in a closer alliance and cooperation between the scientific worker and the actual agencies of production. Such cooperation exists, as we are all beginning to learn, in Germany, and its results are evident throughout the world in the tremendous expansion of German industry.

Since all material is subject to chemical laws and its properties and behavior are influenced or determined by these laws, it follows that a large number, probably by far the greater number, of our industrial problems are problems in applied chemistry. No better field for the initiation of work intended to be directly effective in its bearing upon industrial efficiency could therefore have been chosen by the authorities of the Massachusetts Institute of Technology than that of research in applied chemistry upon some basis which renders the results obtained immediately available to those responsible for the conduct of industrial affairs.

That this institution has found it possible to lead her sister institutions in the establishment of a research laboratory of applied chemistry is due to the generosity of Mr. Charles W. Hubbard in supplying the funds required for the initial organization and beginning of its work.

The general object of the laboratory is that of increasing the efficiency of industrial effort by carefully focussed and directed research in chemistry as applied to particular phases and problems of actual practice, but what gives the laboratory its unique position is the relation in which it aims to stand to industry throughout the country. It will, so far as possible, be made a clearing house for problems in applied chemistry. Many of the expected problems have doubtless been already solved elsewhere, others may at the time be engaging the attention of outside specialists. In the one case the solution will be immediately forthcoming, in the other the laboratory will endeavor to bring the applicant into touch with those studying the problem in other laboratories. There will remain, however, many problems of wide importance in their bearing upon industry and from among these the laboratory will select for its direct attack as many as its funds permit, giving preference always to those which promise in their solution to prove of greatest benefit to the community. Without attempting to indicate the lines along which this public service of the laboratory may develop, one may, by way of illustration, point to such subjects for investigation as the cause and prevention of the corrosion of lead pipe, the breakage of steel rails, the waterproofing of cement structures, the utilization of wastes which now involve nuisance, the study of the atmosphere of street-cars and the conditions underlying proper ventilation, the relation of material and treatment to the brittleness of pottery, or the fireproofing of theatre scenery.

All this, so far as it relates to the Research Laboratory of Applied Chemistry at the Massachusetts Institute of Technology, does not mean that the laboratory will not welcome problems which have a specific and limited application to particular industries; for it is through problems of this class that the laboratory will be brought into closest touch with industry and enabled to make its influence most directly and immediately felt by those whom it would benefit. No propaganda preaching the industrial value of research will make converts half so quickly as the actual solution of the particular problems by which the individual manufacturer is confronted and perplexed. For these reasons, no less than for the more compelling fact that it is to the manufacturers thus aided that the laboratory at this stage of its development must look for its support, a large proportion of its work will be directed along lines suggested by the manufacturers themselves and leading, if successful, to their individual benefit.

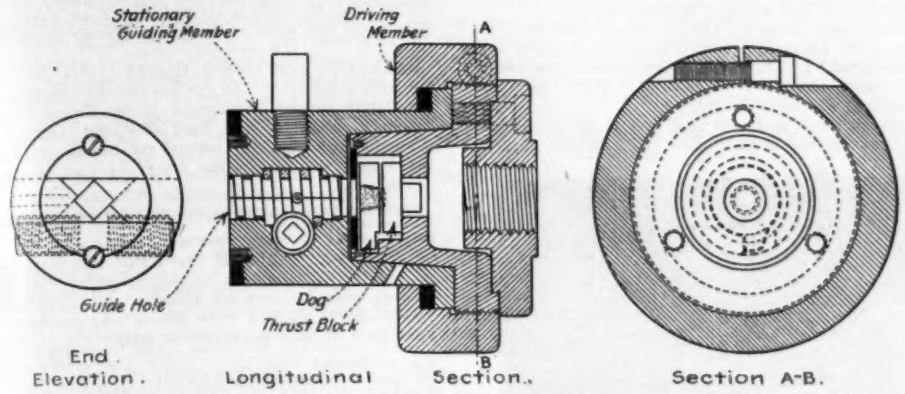


FIG. 3. SECTIONAL VIEW OF CHUCK FOR "RADICAL" DRILL.

The new laboratory will constitute a division of the Department of Chemistry and Chemical Engineering, of which Dr. Henry P. Talbot is the head. To his foresight, breadth of view, and strong support must be attributed much of the promise of its scope and plan. The immediate direction of the laboratory and responsibility for its results will be, however, in the hands of Dr. William H. Walker as Director of the Research Laboratory of Applied Chemistry. Dr. Walker's activities and interests have given him a notably wide general knowledge in the field of chemistry as applied to industry and a direct contact with many special lines of manufacture. His more recent studies, and perhaps his most notable achievements, have been concerned with the corrosion of metals.

Dr. Walker has selected as his Research Associates Dr. Warren K. Lewis, M. I. T. '05, who earned his Ph.D. at Breslau, and Dr. William Guertler, a graduate of Göttingen and later Privatdocent at the University of Berlin, where he specialized in the chemistry of alloys. Both men bring an exceptional equipment to the work. In addition to the research associates, who form the nucleus of the organization, the laboratory staff already includes two half-time assistants, who also devote themselves to instruction and three advanced students working for higher degrees.

The recognition of the importance of the work of the laboratory and its promise of helpfulness has been so prompt and general that already the need for additional funds has become imperative, if even the immediate opportunities are to be seized. The work now under way, which is of the first importance to several of our great industries, includes the study of case hardening as applied to special alloy steels; an investigation into the cause of the "gray sheets" which, because of brittleness, are the occasion of heavy loss to makers of galvanized iron; and a study into the causes determining the presence of pinholes in sheet tin plate. The direct bearing of this last-named problem upon the canning industry, the economy of milk transportation and the permanence of tinned roofs everywhere is obvious. That all will ultimately be solved cannot be doubted in view of the gratifying progress already made.

The terms upon which the services of the laboratory are offered to manufacturers are these:

The laboratory will undertake a specific problem and engage to direct its best efforts towards its solution. The Institute will furnish laboratory facilities and the cooperation of the general instructing staff in a consulting capacity. This phase of the arrangement is of the first importance, since it means that the facilities and organization of the Mechanical and Electrical Laboratories of the Institute as well as those of the Research Laboratory of Physical Chemistry are available for the special assistance they can render in particular aspects of the work.

Reports of progress will be made every three months. The applicant who consigns his problem to the laboratory undertakes to pay the actual time cost of the one or two experimentalists actually engaged upon the work and the cost of special apparatus, but he is free from all expense involved in the direction of the work or which might otherwise result from the expert consulting service of members of the instructing staff not directly connected with the laboratory. When results have been obtained, the original applicant has his option of two courses. He may either permit the Institute to publish the entire investigation for the general good of the community or he may elect to keep the results for his own benefit (either as a secret process or by having them patented in his behalf) by paying to the laboratory, for its purposes of further research, a sum to be agreed upon at that time.

Best of all, the laboratory affords an opportunity for the training of men for other laboratories, in which these methods will be applied to the solution of the problems of manufacturers and public service corporations everywhere. Simultaneously with this training of picked men, will go forward advanced courses in the application of the chemical method of the needs of industry and in seminars on general subjects in chemical technology which will be open to adequately trained students upon election.

NEW HELICAL SPRING FORMULAS have been arranged by Mr. Chester B. Albree and are explained in his paper "Spring Formulas Simplified," which is published in the November issue of the "Proceedings" of the Engineers' Society of Western Pennsylvania. These are not strictly new, being derived from the well-known Reuleaux' formulas:

$$P = S\,\frac{\pi\, d^3}{16\, R}$$

$$F = \frac{32}{\pi}\,\frac{PR^2L}{Gd^4}$$

in which R = radius of coil to center of wire,
L = uncoiled length of wire,

and the other symbols correspond to those used below. The process of simplification is explained by Mr. Albree, in part, as follows:

In comparing the various formulas, it was found that certain quantities could be combined giving formulas of much simpler character and yet equally exact. This was accomplished by cancellations and reductions, eliminating the third and fourth powers and replacing them with areas, diameters and constants. This is done with the intention of rendering the solution of helical spring problems easy for anyone having at hand standard tables of areas and decimal equivalents. The writer is not in the spring manufacturing business and is not an authority on the subject. The formulas derived with the terms used are given below:

$$P = \frac{a\, d\, S}{2\, D}$$

$$\frac{P}{W} = \frac{f}{f_1} = \frac{F}{F_1}$$

$$f = \frac{D^3}{40\, d} \quad \text{for } S = 100{,}000 \text{ lbs.}$$

$$= \frac{D^3}{50\, d} \quad \text{for } S = 80{,}000 \text{ lbs.}$$

$$= \frac{D^3}{67\, d} \quad \text{for } S = 60{,}000 \text{ lbs.}$$

$$n = \frac{H-1}{f+d}$$

$$F_1 = n\,\frac{f\, W}{P} = n\,\frac{D^3\, W}{40\, d\, p}$$

in which P = closing, or maximum permissible, load of spring.
S = torsional strain, outer fiber.
W = any load on spring.
f = deflection of one coil under closing load.
f_1 = deflection under any load.
F = total deflection under closing load.
F_1 = total deflection under any load.
d = diam. of bar or wire.
a = area of bar or wire.
D = diam. of coil, center to center of bar or wire.
H = free height of coiled spring.
n = number of free coils.
G = modulus of torsion.
= 12,500,000 lbs.

The formulas are based on a spring designed so that when it is closed under a certain load, the strain S, selected, will be reached. The deflection formulas give the pitch of coils to produce strain S, when closed. With what is known ordinarily as "spring steel," it is safe to use S = 100,000 lbs., which is the practice of the spring manufacturers of Pittsburg.

The value to be used for S should depend, of course, upon the nature of the work for which the spring is designed and the conditions under which it must operate. The value given above (S = 100,000 lbs. per sq. in.) is rather high for general conditions. The German engineer's pocketbook, "Hütte," gives S = 4,500 kg. per sq. cm. (which is closely equivalent to 64,000 lbs. per sq. in.) for spring steel with fairly constant loading. In springs designed for continual removal and application of load, such as inlet or exhaust-valve springs of gas engines, S should not exceed 45,000 lbs. per sq. in.

An Air-Blast Heater with Straight Tubes.

The design of heater "coil" shown in the accompanying figure has been put out by the Green Fuel Economizer Co., Matteawan, N. Y., to secure a hot blast heater which will be free from troubles with pocketed air or water.

Straight tubes are expanded into box headers. These headers have a cover plate held in place by hook bolts and made tight by a rope gasket lying in a groove. The headers are intended to stand vertically so that when the cover plates are removed all tube ends are exposed for inspection, cleaning or repair. Such work is made quite simple by this design.

The front headers carrying the inlet and discharge connections are divided into two compartments by partitions seen in the figure. Steam then, on being admitted to the upper compartment, flows out through the upper pipes to the rear header and back to the lower front compartment through the lower tubes carrying with it any air that may have collected. The drainage of condensed steam through the tubes and from the header is always in the direction of steam flow.

When the sections are assembled, for hot-blast heating, for drying or similar purposes, the headers fit tightly together so that a casing is required for the bottom and top only. While the "coil" shown was designed for hot-blast heating, it has been found easily adaptable for the use of hot and cold water or brine in the tubes for such installations where a lower-temperature air current is desired.

HOT-BLAST HEATER WITH STRAIGHT TUBES BETWEEN TWO HEADERS.
Made by The Green Fuel Economizer Co., Matteawan, N. Y.

A COAL MINE EXPLOSION at the Yolande mines in Tuskaloosa, Co., Ala., Dec. 16, imprisoned about 50 miners. Only eight of those in the mine at the time of the explosion were able to reach the surface and it is thought probable that the rest were killed.

THE COLLAPSE OF A SCAFFOLD at the Central Blast Furnace, Cleveland, Ohio, Jan. 3, resulted in the death of one laborer and the serious injury of 14 others. The men were tearing down a brick chimney and were working about 30 ft. above the ground when the scaffolding on which they stood gave way.

AN EXPLOSION AT LICK BRANCH, Va., Dec. 29, in the mine of the Pocahontas Consolidated Coal Co. resulted in the death of 49 miners. About 75 men were in the mine at the time of the explosion and 18 of these were able to escape although severely injured. Rescue parties, according to reports of Jan. 2, have recovered 54 bodies of which five were still living. The mine was inspected and favorably reported upon by the State Mine Inspector last August.

FIVE RAILWAY ACCIDENTS occurring between Dec. 28 and Jan. 4 caused the death of 15 people and the serious injury of about 30 others. A head-on collision between a freight and a work train on the Great Northern Ry. took place near Midcanon, Mont., Dec. 28. Nine men were killed and four others injured. The freight train was northbound, loaded with ore, and had orders to pass the southbound work train at the Midcanon siding. For some reason, the freight failed to wait for the work train, and the collision occurred on a curve about one mile north of that station. The work train consisted of a caboose and pile driver pushed by a locomotive with the caboose in the lead, and all but one of those killed and injured were in the caboose. The caboose and pile driver caught fire and were entirely lost.

Two freight trains on the Cleveland, Cincinnati, Chicago & St. Louis Ry. collided head-on four miles south of Knightstown, Ind., Dec. 29. Both locomotives and five cars were completely demolished. Three men were killed and one seriously injured.

Fast mail and passenger train No. 35 on the Southern Ry. was wrecked at Stokesland, Va., Dec. 29. The accident is ascribed to a misplaced switch. The engineer was killed and four others injured. Upon striking the open switch, the locomotive and the baggage and mail cars left the track and were overturned.

A runaway locomotive on the Philadelphia & Reading Ry. crashed into the station at Trenton, N. J., Jan. 3, wrecking the building and severely injuring the engineer. The accident is ascribed to the failure of the air brakes. The locomotive got beyond control on the slight grade and overturned the bumping-post at the end of the branch leading to the station. Several passenger cars became detached from the engine before the station was reached and one of them was derailed.

A fast passenger train on the St. Louis & San Francisco R. R. collided with a freight near Tulsa, Okla., Jan. 4. Two men were killed and 20 were injured. The accident is ascribed to a confusion of orders coupled with a heavy fog.

PREVIOUS AEROPLANE RECORDS were surpassed by Wilbur Wright at Le Mans, France, on Dec. 31, in a flight of 2 hrs., 9 min. The official distance covered was 73 miles, but on account of wide turns the actual distance was nearer 90 miles. It is reported that the flight was made in intense cold.

THE HAVERSTING TUNNEL IN NORWAY was holed through in December, 1908, after 5½ years' work, according to a report of the "Schweizerische Bauzeitung." The tunnel is on the new state railway line from Christiania to Bergen, between Gulsvik and Roa. It is 7,557 ft. long, with a section 15 ft. by 20 ft. The rock was generally a hard gneiss. Drilling was done by hand exclusively, and a maximum advance of 6½ ft. per day per heading was attained.

THE LOETSCHBERG TUNNEL has progressed steadily in its south end, its heading being advanced 510 ft. in November, 1908, so that the total length of heading in the south end on Dec. 1 was 9,538 ft., as reported in the "Schweizerische Bauzeitung." The north heading has remained stationary since the break-in last July, and the only work done since then at this end has been full-section excavation and masonry lining. The heading was closed off by a 20-ft. bulkhead 4,000 ft. back of the face shortly after the accident. A commission of experts was then engaged to report on the best means of going ahead, but their report, though rendered four months ago, has not been made public. Negotiations between the contractor and the Berner Alpenbahn Gesellschaft are still in progress. In November drills were put to work in the creek bed over the point where the break occurred, to give full information about the subsoil. This work will probably not be continued during the winter. In the meantime nothing has been done to regain the face, and pending the result of the borings it is not known how wide is the soft seam or how far it extends laterally.

DELAYS TO PASSENGER TRAINS in New York City are now reported by the various railway companies to the Public Service Commission of the Second District (territory outside of New York City) and tabulated by the latter monthly. The bulletin for October, the latest one issued, summarizes the delays for that month as follows:

From the figures given in the statement, a summary of the totals follows:

Total number of trains reported	57,712
Per cent. of trains on time at division terminal	82
Per cent. of trains late at division terminal	18
Average delay for each late train	22.9 mins.
Average delay for each train run	4.1 mins.

Summary of principal causes of delay:

	Per cent.
Engine failures	7.9
Failures of other equipment	2.5
Wrecks	5.5
Unfavorable conditions of track	2.9
Waiting for trains on other divisions	35.1
Waiting for train connections with other railroads	10.0
Meeting and passing trains	7.6
Signals	1.2
Trains ahead	7.5
Waiting for orders	0.3
Train work at stations	15.2
Storms	0.1
All other causes	4.2

THE ASSOCIATION FOR THE DEFENSE OF SEPTIC process suits has just issued a pamphlet in which the purposes of the association are stated and its recent work reviewed. The first object of the association is said to be to assist the village of Saratoga Springs, N. Y., in determining the damages due from it to the Cameron Septic Tank Co., for use of the septic process. The association also proposes to assist other municipalities in all matters relating to septic process suits. The pamphlet states that the Executive Committee of the association, with the aid of Mr. George W. Rightmire, of Columbus, O., its Executive Counsel, has studied the Saratoga Springs case and collected data designed to aid in "establishing a minimum measure of damages." This measure is based on "the cost of cleaning out thoroughly the septic tank at intervals of six weeks," this being based "on the belief that the trial records indicate that such cleaning avoids infringement of the patent in suit."

After reviewing the record in the Saratoga Springs suit, and after considering a number of other sewage-disposal plants with reference to the septic process patent, the Executive Committee of the association has taken the following position:

(1) It has not been determined that any plant except the one at Saratoga Springs infringes the Cameron patent.

(2) Some process of sewage disposal is necessary and the municipality should not be put to the expense of changing the process for the present, or paying a royalty to the Cameron Septic Tank Co. until it has been determined that there is infringement in a particular case.

(3) The rule for ascertaining the damages sustained by the Cameron Septic Tank Co. has not been determined for any particular case, and even if it should be determined finally that a particular plant is an infringement, the amount due to the Cameron Co. may be small.

(4) There are many prior patents and instances of prior use in the art of sewage disposal to be considered in connection with each plant, and there are questions arising in connection with each disposal plant, the answer to which is uncertain in view of the decision upholding the Cameron patent, the application of the reasoning of the Court to these various cases not being clear.

For the above and other reasons, all members of the association are advised to operate their sewage-disposal plants in the usual way; when the rule for estimating damages has been laid down in the Saratoga Springs case, the association will have more definite information upon which to proceed. If it is eventually found that they do infringe, the association will use its best endeavors to suggest modifications of the construction and operation of the plants to avoid infringement.

Mr. George W. Fuller, M. Am. Soc. C. E., of Hering & Fuller, New York City, has been appointed to represent the association in opposition to any bill that may possibly be introduced in Congress to extend the life of the septic process patents, particularly No. 634,423, which patent expires in November, 1909.

The association now has 30 members, of which 23 are either cities or sewage companies, and the remainder are state officials, engineering firms and individuals. Mr. George A. Johnson, Assoc. M. Am. Soc. C. E., 170

Broadway, New York City, is treasurer of the association, and to him payments for membership in the association should be made. The admission fees, which vary with the population of cities, are given in the pamphlet, which can doubtless be obtained by addressing Mr. Johnson.

SEPTIC TANK PATENTS were discussed at some length by Prof. A. Marston, Ames, Ia., before the convention of the League of American Municipalities at Omaha some weeks ago. He began by classifying sewage tanks as settling, bacterial and septic tanks. Settling tanks are comparatively small, and from these the sludge must be frequently removed; bacterial tanks are larger, permit the action of aerobic, facultative and anaerobic bacteria, and require a considerable amount of sludge removal; septic tanks are designed to exclude all bacterial action except anaerobic, and to dispose of considerable quantities of sludge by the anaerobic action. The author then proceeded to review the recent decision of the United States Circuit Court of Appeals upholding the Cameron septic tank patents, which decision was his reason for suggesting the classification just outlined. Two paragraphs from his paper may be quoted as follows:

Since the septic tank idea gained favor, every designer of sewage tanks, the writer among the number, has used the name septic for his tank, and apparently with good reason, for originally the word septic simply referred to bacterial conditions, just as the word anti-septic refers to anti-bacterial conditions. Since the court, however, has legally defined septic action to refer to the action of one class of bacteria only, let us accept such definition, even if it be regarded as artificial and illogical.

It is impossible, at present, to state just what features of design and operation are essential to the difference between bacterial tanks and septic tanks, as such tanks are defined above. Indeed, the same tank may be bacterial or septic depending on the method of operation. It must be remembered that the apparatus claims of the septic patents were not sustained, so that there are no patents on any particular kind of sewage tank. Any municipality or person may build any kind of a sewage tank desired, and be guiltless of infringement, provided the tank is not operated in such a way as to prohibit every sort of bacterial action in it, except anaerobic. We may infer from the language of the decision quoted above, that emptying the tank upon a sludge bed once in six weeks or less, would obviate infringement. The expense of doing this would be very small, as in most plants the tanks can be emptied by simply opening a valve. In many cases the sludge could be allowed to remain without nuisance upon sludge beds, where it would largely be destroyed by bacterial action.

Prof. Marston further says:

(1) The claims upheld were declared valid on the ground that certain prior sewage tanks were not anticipations, and hence any tank closely on the plan of these prior tanks in design and operation will not be infringements.

(2) The claims upheld were declared valid on the ground that what the patentee first invented and applied was the idea of excluding all but anaerobic action in a sewage tank, and hence tanks which do not, by their design or method of operation, exclude agitation and the presence of free oxygen and aerobes at the outlet will not be infringements.

THE INJUNCTION AGAINST 80-CT. GAS in New York City has been dissolved by a unanimous decision of the U. S. Supreme Court. The decision, which was handed down on Jan. 4, 1909, reverses the U. S. Circuit Court for the Southern District of New York. The effect of the decision is not to declare that the 80-ct. gas rate is legal or nonconfiscatory, but merely that the company has not proved its claim to the contrary. The case is dismissed without prejudice, so that the company can again bring the matter into court. In arriving at its decision, the Supreme Court seems to have been governed very largely by an opinion that the franchise valuations, as fixed at the time of consolidation ($7,781,000), should enter into the capital of the company, instead of the much larger valuation considered by the lower court, which valuation, in turn, had already been largely scaled down from the claims of the company. The decision just rendered states that, after reducing the franchise valuation found by the lower court, the evidence indicates earnings of almost 5½% on capital. A small reduction in the value of real estate, plants, etc., would bring the return to, if not above, 6%, while it is probable that increased consumption of gas, due to a lowering of the rate, would increase the revenue without corresponding increase in cost. A relatively minor point in favor of the company is the declaration by the court that the legislative requirements for uniform gas pressure are unconstitutional. What may prove to be a very important point in favor of the company in the future is the declaration of the court to the effect that the present value of the franchise held by the company should be taken into account in fixing present rates. The decision itself was concerned with the rates charged several years ago. The 80-ct. gas rate was established by the State Legislature in 1906, after investigation of gas charges in New York made by a legislative committee. Since the case was taken into the courts, the two companies operating in Manhattan and the Bronx have continued to collect gas charges at the $1 rate, but, by order of the court, have set aside 20 cts. on every 1,000 ft. The fund thus accumulated now amounts to about $9,000,000 not including the small interest allowance which it is expected will be made. This sum will be refunded to those holding receipts.

AN INTERSTATE COMMISSION ON THE MURRAY River and its tributaries (Australia) is proposed by the governments of New South Wales, Victoria and South Australia. Negotiations to this effect have been under way for some time past, and a draft of an agreement providing for the commission and defining its powers has been sent to us by Mr. Elwood Mead, M. Am. Soc. C. E., Chairman of the State Rivers and Water Supply Commission, Melbourne, Victoria. The draft provides for three commissioners, one to be appointed by the Governor of each of the States named. The object of the commission is to improve navigation, to further water conservation and irrigation, and to promote interstate communication. Apparently some storage works are contemplated, to be carried out jointly by the three States. The diversion of water from the river is also to be under the control of the commission, it appears.

THE POLLUTION OF THE DELAWARE RIVER was dealt with at length in a paper presented before the New Jersey Sanitary Association on Dec. 5 by Mr. Harry M. Herbert, M. Am. Soc. C. E., of Bound Brook, N. J. Mr. Herbert is Chief of the Division of Sewerage and Water Supplies of the New Jersey State Board of Health. Mr. Herbert stated that, including the sewage of Philadelphia and Camden, there is discharged into the Delaware River and its tributaries at and above Philadelphia nearly 190,000,000 gals. of sewage per day, as compared with a dry-weather river flow of about 1,280,000,000 gals. The problem of controlling the pollution of the Delaware is made more difficult by the fact that its drainage area lies in New York, New Jersey and Pennsylvania, and the control of pollution is of great importance because the stream is used for public water-supply by many Pennsylvania and New Jersey cities and towns. The drainage area of the river lying within New York State is relatively small, and the population on that area is also small in comparison with that in the other two states. No public water-supplies are taken from the river by either Pennsylvania or New Jersey within a distance of 53 miles from the point where the stream leaves New York, the first municipality to take such a supply being Belvidere, N. J. Within the state of Pennsylvania, the Delaware has a drainage area of 6,574 sq. mi., on which is a population of 2,456,000. With the exception of four municipalities, none of the Pennsylvania population contributing to the pollution of the Delaware has sewage-treatment works. In New Jersey the drainage area of the Delaware is 2,345 sq. mi., or 44% of the area of the state, and the population is 466,000. Directly, and indirectly through tributaries, the Delaware River receives the sewage of 48 New Jersey municipalities, only 12 of which have established sewage-treatment works. The other New Jersey towns, the sewage of which is discharged into the river, have been ordered by the State Board of Health [or its predecessor, the State Sewerage Commission] to submit plans for sewage-disposal plants, and to have the plants in operation at specified dates, the latest of which is in 1913. Phillipsburg, N. J., is contesting one of these orders in the Court of Chancery. The State Department of Health of Pennsylvania has ordered sewage-treatment plants for many of the Pennsylvania towns now discharging into the Delaware, and some of these municipalities have plants under construction. Mr. Herbert states that "New York will doubtless follow the steps of New Jersey and Pennsylvania in this respect, although not an offender to such an extent as the sister territories." But, Mr. Herbert adds, the establishment of sewage-treatment plants is not sufficient. State boards should be given "absolute control of the workings" of sewage-treatment plants, "with power to cause such changes to be made from time to time as appear to be necessary." Even when all this has been done, "it will be necessary to filter the water-supplies taken from the river."

MUNICIPAL GOVERNMENT BY SMALL COMMISsions in place of the traditional city council is being adopted here and there throughout the country. A scheme for a commission plan has been worked up for the city of Portland, Me., by a committee acting in conjunction with Mr. James P. Baxter, Mayor of that city. The scheme seems to follow in some respects that recently adopted for Des Moines. The commission proposed in the report of the committee would be composed of five members, known individually as the Mayor and Aldermen and collectively as the council. Provision is made for the appointment of city employees under civil service rules, for recalling by popular vote the holder of any elective office, and for submitting all franchise ordinances to popular vote. The Mayor would have all the powers now vested in him under the old charter, with the exception of that of veto. He would have a vote on all questions coming before the council, as the commission would be called. The Mayor would hold office for two years, and the four Aldermen, or other members of the commission or council, would be elected at large, two in each year. The salary of the Mayor would be $2,500 a year and of the Aldermen $2,000 each, and these officials would be required to devote their whole time to the business of the city. The report of the committee must be acted upon favorably by the City Council and the Legislature, and then adopted by popular vote before the new plan of government goes into effect.

PANAMA CANAL EXCAVATION during December totaled 3,261,673 cu. yds., a daily average of 125,449 cu. yds. for 26 working days, as against 2,920,494 cu. yds., a daily average of 126,978 cu. yds., for the 23 working days of November. The record for the past two months is as follows:-

Steam Shovels:	December.	November
Atlantic division	128,203	130,710
Central division	1,527,185	1,321,692
Pacific division	133,189	115,553
Dredging:		
Atlantic division	679,604	570,832
Pacific division	675,766	711,479
Canal prism total	3,143,947	2,850,266
Accessory work outside canal prism:		
By steam shovel	109,143	70,228
By dredging	8,583	.....
Total excavation	3,261,673	2,920,494

The rainfall during December was 5.93 ins. against 11.66 ins. in November.

CAR LIGHTING IN CANADA is regulated by a recent order of the Dominion Railway Commission. In future cars must use either Pintsch compressed oil-gas, acetylene gas or electricity. This eliminates the oil lamp. Fines for offences against this order are fixed at $100 for the railroad and $20 for employee or official, for each offence.

COST OF OPERATING TURNTABLES.—A Hand-operated locomotive turntable at the Lincoln Park shops of the Buffalo, Rochester & Pittsburg R. R. was recently equipped with an induction-motor driven donkey by the Westinghouse Electric & Manufacturing Co. The table as formerly used required the time of several men at intervals so that the average labor required was that of two men for 24 hours per day. With the electric donkey the labor required was cut in two. The men were paid 15 cts. per hour and the saving of the new arrangement over the old was then $3.60 per day or $1,314 per year of 365 days. Against this had to be charged the cost of power at $8 per month or $96 per year. If an investment charge of 5% on the cost of change ($1,500), amounting to $75, and a depreciation and repair charge of 5%, amounting to $75, are charged against the labor saving, then the net saving is $1,068 per year. This is an earning of about 71% of the cost of change. As a result of the satisfactory operation of this particular table, four other installations have been made by this railroad and others are contemplated.

SEWAGE PURIFICATION WORKS at Sheffield, England, treated an average of 20,856,000 U. S. gals. of sewage per day during the year 1907-08, according to the annual report of Mr. Charles F. Wike, M. Inst. C. E., City Engineer. All save about 1,200,000 U. S. gals. per day was treated by lime precipitation alone. The smaller amount named was treated on various experimental filter beds, "with satisfactory results." The report states that analyses of the effluents showed that it had been "possible to maintain a standard of purification from single contact beds approximating to the standards of the Rivers Board, and by double contact to exceed these requirements." The report also states:

It is noteworthy that when single contact effluents have slightly infringed the oxygen absorption standard, they have still been incapable of putrefaction, and have satisfactorily held dissolved oxygen.

The capacities of the beds have been well maintained, and it appears probable that if efficient tank treatment can be secured, the renewal of material will not be so frequent as to be unduly expensive.

A total of 61,900 short tons of sludge resulted from the chemical treatment, of which all but 572 tons were sent to a dump heap. The 572 tons were "sent to farmers." Inasmuch as the report states that up to March 25, 1908, a total of 876,000 short tons had been sent to the Kilnhurst dump, it may be inferred that the utilization of sewage sludge by farmers in the city of Sheffield has for years past been reduced to as small a figure as is reported generally from other works—if indeed any large quantities of Sheffield sludge were ever taken by the farmers.

Mr. Wike reports that satisfactory progress is being made on the first installment of the new sewage treatment works, which are to cost approximately $1,312,200, and are to treat 76,800,000 U. S. gals. per day. The whole of the quantity named will be passed through catchpits and settling tanks, and half of it will be treated on single contact beds. Any sewage in excess of 38,400,000 U. S. gals. will be sent to the storm beds. The exact nature of the settling tanks is not stated, but it is said that the total tank capacity of 19,200,000 U. S. gals. will be available, old and new tanks included.

There will be 60 first contact beds having an area of ½-acre each, and 16 storm beds, each with an area of 1 acre. At present about $487,000 has been made available, and with it 6 of the proposed 9 new settling tanks, and 24 of the 60 first contact beds, are being constructed. Should second contact be found necessary, an additional appropriation will be required. Apparently clinker is to be used as the material for the contact beds, for the report states that 21,000 short tons have already been retained, while 60,000 will be required for the beds now in hand and 216,000 for the complete scheme.

TEN MILLION WOOD PAVING BLOCKS are now in place in the streets of Sheffield, England, according to the annual report of Mr. Charles F. Wike, M. Inst. C. E., City Engineer, for the year 1907-08. Mr. Wike states that the average life of wood blocks in Sheffield "is probably ten years, as compared with a period of seven years, which is usually considered a fair average" elsewhere. He attributes the longer life of wood pavement in Sheffield "to the strict supervision which has been exercised over the supplies of wood blocks." He mentions increasing difficulty in procuring satisfactory wood blocks, owing to the available supply being apparently less than the demand. The city has a creosoting plant, at which all its wood blocks except those from hard woods are treated by its own workmen. The plant has a capacity of about 30,000 blocks per week if worked night and day, but is declared by Mr. Wike to be inadequate, so that the question of establishing a new plant is under consideration. It would seem, by the figures given above, that, quite aside from extensions, about 1,000,000 wood blocks are required in Sheffield yearly.

FLOOD PREVENTION MEASURES at Topeka, Kans., have been reported on at some length by Capt. Schulz, of Kansas City, who was detailed by the Chief of Engineers, U. S. A., for the purpose. The report, it should be understood, is unofficial, having been made by the courtesy of the War Department. The gist of the recommendations made by Capt. Schulz is that there be provided a river channel 1,000 ft. wide at all points, and that to this end all bridges be either raised or lengthened, or both lengthened and raised, so as to give a cross-sectional water area of at least 30,000 sq. ft.; also, that levees be built along the Kansas River and the south bank of Soldier Creek, so as to confine the streams within the high-water mark (32.7 ft.) of the flood of 1903. Alternative propositions for lengthening or raising the various bridges involved are given in the report. No estimates of cost are submitted. In making the report, Capt. Schulz was assisted by Mr. John P. Rogers, City Engineer, who made surveys of 21 miles of the river. Before the city can take action in the matter, it will be necessary to secure the creation of a drainage district under the state law, or else get some other legislative authority.

Personals.

Mr. T. P. Shonts has been elected President of the Interborough Rapid Transit Co., succeeding Mr. E. P. Bryan, resigned.

Mr. Horace G. Burt has been appointed Receiver of the Chicago Great Western Ry., succeeding Mr. A. B. Stickney, resigned.

Mr. Richard Wallace, Superintendent of the Buffalo Structural Steel Co. for the past nine years, resigned that position Jan. 1.

Mr. W. J. Knox, who has been employed on the Panama Canal for the past two years, has opened a general engineering office in Woodburn, Ore.

Mr. A. D. Parker, Vice-President of the Colorado & Southern Ry., will succeed Mr. Frank Trumbull as President. Mr. Parker began his railway career as a section hand on the Denver & Rio Grande R. R.

Mr. E. I. Ford has been appointed Superintendent of Terminals of the Chesapeake & Ohio Ry. at Newport News, Va. The office of Trainmaster of Terminals, formerly held by Mr. Ford, has been abolished.

Messrs. William R. Patterson, plant engineer of the Western Electric Co., and Frank E. Davidson, architect and engineer of construction of that company, have formed a partnership as constructing and industrial engineers, with offices at 1448 Monadnock Block, Chicago.

Mr. C. W. Jones, Division Superintendent of the Chicago, Rock Island & Pacific at Des Moines, Ia., is to be General Superintendent of the Southwestern District with office at Topeka, Kan., succeeding Mr. A. E. Sweet, who has been made Assistant to the Second Vice-President.

Mr. Frank D. Lyon, of Binghamton, N. Y., has been appointed Special Examiner of Highways by Mr. Frank M. Williams, State Engineer and Surveyor of New York. Mr. Lyon is to serve until the new State Highway Commission, to be appointed by Governor Hughes, formally assumes office.

Mr. H. Rittinghouse has been appointed Division Engineer of the Iowa and the Iowa & Minnesota divisions of the Chicago & Northwestern Ry., with office at Boone, Iowa. Mr. J. A. S. Redfield is appointed Division Engineer of the Northern Iowa & Sioux City divisions with office at Sioux City, Iowa.

Mr. William B. Dickson, Second Vice-President of the United States Steel Corporation, has been elected First Vice-President to succeed Mr. James Gayley, M. Am. Inst. M. E., whose resignation was noted in this column Nov. 26. Mr. David G. Kerr, M. Am. Inst. M. E., will succeed Mr. Dickson as Second Vice-President.

Mr. H. W. Sykes, Assoc. Am. Inst. E. E., has retired from the firm of Connell, Sykes & Connell, Engineers, 90 West St., New York City. Mr. H. W. Connell, Assoc. Am. Inst. E. E., and Mr. H. F. Connell, Assoc. Am. Inst. E. E., will continue as consulting engineers at the same address under the firm name of Connell & Connell.

Mr. C. T. Bissell, Assoc. M. Am. Soc. C. E., has resigned as Resident Engineer of the Brighton Beach Improvement, Brooklyn Heights R. R., to take a position as Structural and Electrical Engineer with the Committee on Fire Prevention of the National Board of Fire Underwriters. His address will be 135 William St., New York City.

Obituary.

Achille L. Archambault, founder of the Kensington Engine Co., died Dec. 28 at his home in Philadelphia. He was the inventor of the portable engine manufactured by that company. He was 87 years old and had retired from business six years ago.

George W. Hough, Professor of Astronomy at Northwestern University and Director of the Dearborn Observatory, died Jan. 1 at his home in Evanston, Ill. He was born in Montgomery Co., N. Y., in 1836. He has made a systematic study of the planet Jupiter and discovered more than 600 new double stars. Mr. Hough was the inventor of several instruments pertaining to astronomy, meteorology and physics and the author of numerous articles in scientific journals.

Benjamin F. Clarke, Professor Emeritus of Mechanical Engineering at Brown University, died at his home in Providence, R. I., Dec. 20. Mr. Clarke was born in Newport, Me., in 1831, and graduated at Brown University in 1863. He continued at the University as an instructor in mechanical engineering and rose to the rank of Professor. In the absence of the President of the University, Mr. Clarke served on two occasions as Acting President. He was made Professor Emeritus at the time of his retirement in 1905.

Daniel D. Carothers, Chief Engineer of the Baltimore & Ohio R. R., died Jan. 1 after an illness of five days. He was born in 1860 in Washington Co., Ohio. He entered the service of the Wheeling & Lake Erie R. R. as a rodman in 1882, became Assitant Engineer of that line the following year and, in 1885, became Chief Engineer of the Columbus & Cincinnati Midland. He remained in this position until, in 1890, he was made Engineer of Maintenance of Way of the Baltimore & Ohio Southwestern Ry., at Cincinnati, and entered the service of the Baltimore & Ohio R. R. as a division superintendent in 1901. He became Chief Engineer in February, 1904.

Isaac W. Maclay, Major, U. S. A., retired, died Dec. 29 at his home in Yonkers, N. Y. Major Maclay was born in New York City in 1841 and was educated at New York University, afterward attending the Military Academy at West Point, where he graduated in 1864. He was one of those who carried President Lincoln from Ford's Theatre after his assassination in 1865. His service in the army was mainly in the Ordnance Corps. He retired in 1867 to become Assistant Topographical Engineer of the Department of Parks of New York City and was in charge of the laying out of the streets and avenues north of 155th St. and of the 24th and 25th Wards. After his resignation from the Department of Parks, he became Chief Engineer of the Long Island R. R., and later entered into partnership with Mr. William E. Davies in the real estate business under the firm name of Maclay & Davies. He was actively engaged in the business of this firm up to the time of his death.

Edward Frost, a retired civil engineer, died in Newton, Mass., July 9, 1908. A paper written by Mr. George A. Kimball, M. Am. Soc. C. E., Chief Engineer of the Boston Elevated Ry., and published in the "Proceedings" of the Littleton (Mass.) Historical Society presents the following points of interest in Mr. Frost's career: Mr. Frost was born at Wayland, Mass., in 1832 and attended the public schools of that town until his father's death in 1838, when he went to Framingham, Mass., where he attended the Framingham Academy, of which his father, Dr. Edward Frost, had at one time been the principal. In 1842 he entered the Lawrence Academy at Groton, Mass., and graduated in 1846. In public exercises given by this school in 1845, Mr. Frost, only 13 years old at that time, delivered the valedictory address in Latin. Immediately after graduating at Groton, he entered Harvard University and graduated with honors in 1850. His first experience in civil engineering was gained in the office of Stearns & Sanborn, of Charlestown, Mass. In 1861 and earlier, he was engaged with Gen. M. C. Meigs on the construction of the Washington aqueduct, which is carried over Cabin John Creek by the longest stone arch span in America. From 1863 to '67 he was in the service of the U. S. Government in charge of fortification and railway construction in Florida and North Carolina. In 1867 he opened an office in Boston with his brother, Benjamin, under the name of Frost Brothers, Civil Engineers, and assisted him in the following year in preliminary study for the Hoosac Tunnel, of which Benjamin Frost was Chief Engineer. Edward Frost was City Engineer of Somerville, Mass., from 1868 to '71, and from 1869 to '75 was Chief Engineer of the Massachusetts Central R. R., extending from Boston to Northampton. He continued in general office practice until 1890, when he retired. Mr. Frost is survived by his wife, formerly Miss Ellen Muzzey, who lives now in Newton, Mass.

Engineering Societies.

COMING MEETINGS.

NATIONAL ASSOCIATION OF CEMENT USERS.
Jan. 11-16. Annual convention at Cleveland, Ohio. Secy., Geo. C. Wright, Harrison Bldg., Philadelphia, Pa.

IOWA ENGINEERING SOCIETY.
Jan. 13-14. Annual convention at Waterloo, Iowa. Secy., A. H. Ford, Iowa City, Iowa.

MICHIGAN ENGINEERING SOCIETY.
Jan. 12-15. Annual convention at Ann Arbor, Mich. Secy., Alba L. Holmes, 574 Wealthy Ave., Grand Rapids, Mich.

INDIANA ENGINEERING SOCIETY.
Jan. 14-16. Annual convention at Indianapolis, Ind. Secy., Charles Brossman, Union Trust Bldg., Indianapolis, Ind.

AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS.
Jan. 19. Annual meeting at New York City. Secy., W. M. Mackay, P. O. Box 1818, New York City.

WOOD PRESERVERS' ASSOCIATION.
Jan. 19. Annual meeting at Chicago, Ill. Secy., C. W. Berry, Union Pacific R. R., Topeka, Kan.

AMERICAN SOCIETY OF CIVIL ENGINEERS.
Jan. 20. Annual meeting at New York City. Secy., Charles W. Hunt, 220 West 57th St., New York City.

OHIO ENGINEERING SOCIETY.
Jan. 26-28. Annual convention at Columbus, Ohio. Secy., Paul Hansen, Harrison Bldg., Columbus, Ohio.

ILLINOIS SOCIETY OF ENGINEERS AND SURVEYORS.
Jan. 27-29. Annual meeting at Chicago, Ill. Secy., E. E. R. Tratman, 1636 Monadnock Block, Chicago.

CANADIAN SOCIETY OF CIVIL ENGINEERS.
Jan. 28. Annual meeting at Toronto, Secy., C. H. McLeod, 413 Dorchester St., W., Montreal, P. Q.

NATIONAL BRICK MANUFACTURERS' ASSOCIATION.
Feb. 1-6. Annual convention at Rochester, N. Y. Secy., T. A. Randall, Indianapolis, Ind.

CONNECTICUT SOCIETY OF CIVIL ENGINEERS.
Feb. 9. Annual meeting at Hartford, Conn. Secy., J. Frederick Jackson, Box 1304, New Haven, Conn.

NEW ENGLAND GAS ASSOCIATION.
Feb. 17-18. Annual meeting at Boston, Mass., Secy., N. W. Gifford, East Boston Gas Co., East Boston, Mass.

CENTRAL RAILWAY CLUB.—The annual meeting will be held in Buffalo, N. Y., Jan. 8. Mr. Cecil Lightfoot, Chief Engineer of the Linde Air Process Co., will present a paper on the oxy-acetelene method of welding and cutting.

CANADIAN SOCIETY OF CIVIL ENGINEERS.—At the meeting of the General Section, which will be held at Montreal Jan. 7, the following papers will be read: "Some Notes on a Method of Obtaining Time and Latitude," by G. Blanchard Dodge; "On the Variation of the Coefficient of Discharge, for Small Orifices," by T. P. Strickland.

AMERICAN CHEMICAL SOCIETY.—The regular meeting of the New York Section of this society will be held at the Chemists' Club, 108 West 55th St., New York City, on Friday, Jan. 8, at 8.15 p. m. The meeting promises to be of unusual interest to engineers and manufacturers and is held in conjunction with the Chemists' Club, the Society of Chemical Industry, the American Electrochemical Society and the American Institute of Chemical Engineers.

The principal subject of the evening will be "The United States Patent System; Its Use and Abuse." The following speakers are announced:

Mr. F. I. Allen (late Commissioner of Patents) Introduction: Historical and Descriptive.

Mr. W. Hastings Swenarton (of the New York Bar, late of the Examining Corps, U. S. Patent Office) on "Patents, Trade Secrets and Trade Names as Factors in Industrial Development—Their Relative Functions."

Mr. Louis C. Raegener (of the New York Bar), on "Some Defects in the Practice of our Patent System and Suggested Remedies."

Mr. B. C. Hesse, on "Some Suggestions as to Desirable Improvements."

Mr. L. H. Baekeland, on "The Inventor's Standpoint."

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